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Biennial Crop Pest and Horticultural Report

1911-1912

Oregon Agricultural College
Experiment Station
Corvallis, Oregon

The bulletins and publications of this station are sent free to all residents of Oregon who request them

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This report embodies the results of two years' work in accordance with Senate Bill 31, 1911.

"An act to appropriate Fifteen Thousand Dollars for the expense of investigations by the State Agricultural College at Corvallis, Oregon, for crop and fruit pests and diseases and horticultural problems in the State of Oregon."

This law was enacted at the urgent solicitation of prominent horticulturists throughout the state, and the report unquestionably indicates the wisdom of the movement.

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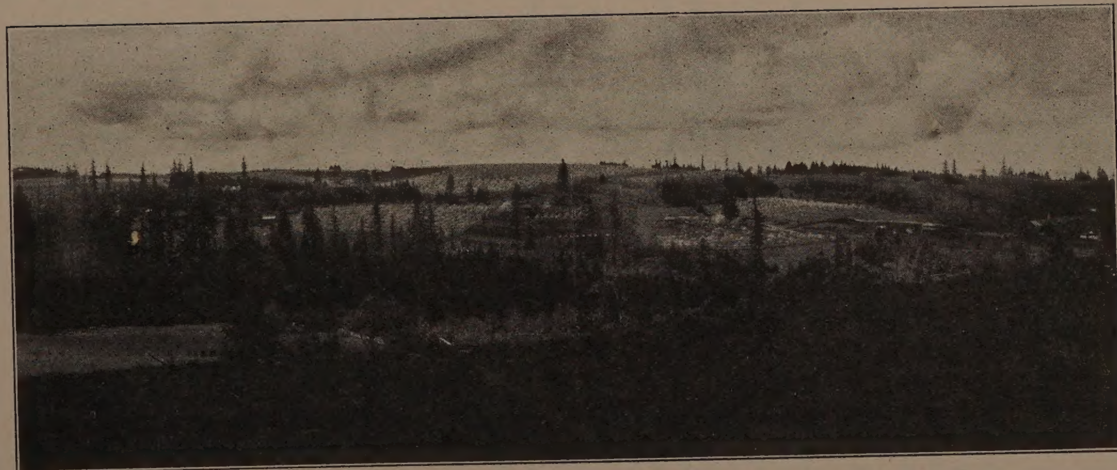

Fig. 1. General view of a typical prune growing district.

Report

OF

Division of Horticulture

PREFACE.

The report of the Division of Horticulture contains eight chapters, including the subjects of the prune survey, frost fighting, frost injury, tomato investigations, fruit evaporation, Loganberry culture, variety adaptation and bud variation. These, however, are only a few of the problems upon which the Division of Horticulture is at work at the present time. In addition to the subjects enumerated, we are also conducting investigations at this time on the fruit pit and winter injury, on irrigation of the apple, soil fertility, which includes the use of fertilizers in apple and prune orchards, growing of cover crops, shade crops, use of manures, composts, etc.; plant breeding, including such crops as the apple, pear, cherry and prune and investigation of fruit evaporation in connection with the Loganberry investigations, as to culture, pruning, training, etc.; nut culture, the college having established a trial garden of various varieties of nuts; vegetable gardening investigations, including the forcing of vegetables under glass, the production of winter vegetables, such as broccoli and cultural and fertilizer investigations in connection with the onion.

It may be several years before reports will be made on certain of these problems, but we take the privilege at this time to let the growers of the state know the nature of the problems upon which we are at work.

C. I. L.

A PRUNE SURVEY OF OREGON.

By C. I. LEWIS, F. R. BROWN, F. C. BRADFORD.

Introduction.

During the summer of 1911 the Division of Horticulture started a prune survey of the state. Work was conducted in nine counties, including Douglas, Lane, Marion, Lincoln, Wasco, Union, Yamhill, Polk and Washington. The survey covered some 700 prune orchards and the field work extended over four months, the figures being compiled largely by Mr. F. C. Bradford and Mr. F. R. Brown. The object of the survey was to find out the true status of the prune industry at the present time. There has been a great renewal of interest in prunes in this state. In writing to prune growers and visiting a number of them much diversity in opinion as to best practices is encountered.

The data which we have collected are far from being conclusive and complete in many instances. This was due in many cases to the prune growers not being able to furnish us with the data that were desired. We have been able, however, to make such observations as to put us in close touch with the most serious conditions concerning the prune grower. Already, as a result of this survey, several investigations are under way. We are hoping that it will be the means of building up a heartier co-operative spirit among the prune growers of the state which will result in better methods in what will be recognized as the common practices for prune growing. A more intimate knowledge of the business, a little more co-operation and a better standardization of the orchards are evidently some of the chief needs of the fruit growers.

I wish to take occasion here heartily to thank the fruit growers of the state who so willingly co-operated in giving us the data which have aided us in our work.

C. I. L.

Varieties.

The Italian (Fellenberg) is the one variety that dominates the prune industry of the state. This is even more true today, after the introduction and exploitation of numerous new varieties, than it was 10 or 20 years ago. Formerly a common recommendation was that one-third of a prune orchard should be planted to the Petite (Agen or French) and the rest to Italian; at present hundreds of acres of young Italians may be found without a single tree of any other variety.

This condition has its explanation chiefly in facts which need not be discussed here. Suffice to say, that the Italian seems peculiarly adapted to the northwest and brings good prices. No other prune comes so near filling both these requirements as does this variety. The Italian has its faults; it is rather likely to be an uneven bearer; the tree is peculiarly susceptible to hot weather, and it ripens its fruit a week or so later than is desirable, making loss from fall rains a considerable item at times.

TABLE I.

County.	Italian		Petite		Silver		Sugar		Champion	
	Orchards Reporting.	Acres.	Orchards Reporting.	Acres.	Orchards Reporting.	Acres.	Orchards Reporting.	Acres.	Orchards Reporting.	Acres.
Douglas	143	1423.55	97	657.50	16	28.25	......	......	......	......
Lane	45	453.5	8	33.5	3	3.5	......	......	......	......
Wasco	22	151.5	1	.5	......	......	......	......	......	......
Umatilla	41	177.05	1	1.0	1	2.0	......	......	......	......
Union	15	115.6	3	8.4	......	......	......	......	......	......
Yamhill	85	1518.25	30	85.75	1	.75	1	12.0	2	1.25
Marion	126	2115.1	59	269.15	7	.75	4	5.5	4	6.0
Polk	62	1025.45	10	6.65	3	1.75	3	1.9	1	0.75
Washington	27	337.25	2	1.25	......	......	......	......	......	......
Total	566	7318.25	211	1063.7	31	37.0	8	19.4	7	8.0

In twelve orchards the following varieties were found in numbers varying from a few to two or three hundred trees: Pacific, Willamette, Clairac Mammoth, Tragedy, Hungarian, Columbia and Tennant.

The main objection to the Petite is its small size. It dries heavier than the Italian and, size for size, it sells a little higher; it is a more regular bearer and therefore its average yield per acre is greater. The small size of the fruit, however, outweighs all these advantages, and vast numbers of Petite trees have been grubbed out or worked over to Italian. It is the leading prune, however, in the southern part of Douglas County, and near Newberg a number of growers have found the Petite more satisfactory. The fact remains, nevertheless, that Italians, because they are larger, bring more money. Very few Petites are to be found in the younger orchards. Petite trees require different handling than Italians, especially as regards pruning. The tree grows as dense as the Italian, therefore the pruning should incline toward thinning of the fruit bearing wood.

Fig. 2. An Italian prune orchard showing good cultivation and July drop.

Very few people who have grown the Silver (or Coe's Golden Drop) recommend it as a commercial prune. The chief objections are (1) that it bears too heavily; (2) that it is late in ripening; (3) that it is subject to fungous diseases and winter killing; and (4) that the fruit does not dry well unless it is previously bleached. On the other hand, when well dried, the Silver is large and good to look upon, brings a much better price than the Italian and is a good variety for canning. A few skillful people supplying special markets have been very successful with it. To the average man, however, it is not to be recommended except as a variety for home use.

The Sugar prune has been very extensively advertised as the variety to supplant the Italian. So far as Oregon is concerned, however, the Sugar is a failure as a commercial variety. The trees are not hardy, they overbear, lack vitality, do not resist disease, and break down easily. The fruit dries poorly, losing weight badly, and on the tree it is liable to bad infestation by brown rot. When dried, it is frequently sold with the Italian prunes. It ripens a few days earlier than the Italian and is a fairly good variety for the home orchard.

Hungarian is grown very little in Oregon, either for drying or for shipment in the fresh state. It is not a good drying prune. It comes into bearing earlier than the Italian, however, and as a variety for selling fresh it is more successful, especially in the local market.

Columbia, Tennant, Willamette, Pacific, Dosch and German prunes have not been very extensively tried and in the survey very little exact information concerning them could be gathered; in fact, not enough to justify drawing any definite conclusions as to their qualities.

Age of Orchards.

TABLE II.

Age of Orchards....	1 to 3 yrs.		4 to 7 yrs.		8 to 11 yrs.		12 to 15 yrs.		16 to 19 yrs.		20 and older	
COUNTY.	No.	Acres.	No.	Acres.	No.	Acres.	No.	Acres.	No.	Acres.	No.	Acres.
Douglas	14	112.75	6	30.6	16	225.7	50	581.8	49	680.2	33	489.25
Lane	1	1.0	....	....	8	177.5	14	150.0	13	115.0	13	90.0
Wasco	....	....	1	1.0	3	46.5	4	22.0	9	54.5	5	34.5
Umatilla	17	49.5	9	31.55	2	5.5	4	12.25	8	79.5	1	2.5
Union	....	....	1	7.0	2	4.5	8	81.5	5	21.0	....	....
Yamhill	10	122.25	9	119.0	10	94.25	30	249.0	33	533.5	14	233.0
Marion	43	422.0	30	315.25	9	98.0	30	382.5	55	979.5	18	251.25
Polk	27	258.25	15	238.5	19	149.25	14	89.5	16	219.0	5	79.5
Washington	11	56.0	11	67.5	5	53.0	8	66.5	12	62.0	4	33.5
Total	123	1021.75	82	797.41	74	844.20	162	1745.5	200	2744.2	93	1213.5

Table II gives a reasonably fair view of the state of prune growing in the various counties of Oregon. The counties where the best methods of growing are employed and the best results obtained are, in general, the ones where young orchards are being set extensively. The figures for the state as a whole show quite markedly the result of the years when prunes brought little money, in the fact that few trees were planted at that time.

If the life of the prune tree shall prove as short as has been sometimes claimed, it will not be long before more orchards are dying off than are coming into bearing. It is doubtful, however, if prune trees in the northwest will prove as shortlived as the plum trees of other regions. Some few who own orchards over 20 years of age think that the period of maximum yield has passed; others, however, similarly situated, notice no falling off as yet. There are a few Italian prune trees in the state nearly 40 years old still bearing heavy crops; these trees have received good care. It is probable that the falling off reported is due to certain soil conditions through diminished fertility or too close planting, rather than from old age itself. It must be remembered that many of the prune orchards in the state were planted on land that had previously been cropped continuously to wheat for nearly 40 years, and the constant drain of heavy crops of fruit has been no small item. Hence before grubbing out an orchard because it is "too old," the owner should be sure that it is not the fertility factor that needs attention.

Distance from Shipping Point.

Because of the fact that prunes are marketed for the most part in an evaporated state and suffer little from long hauls over rough roads, the prune grower seems less confined in his choice of location than the grower of most other fruits. His fruit does not require the quick disposal necessary for a more perishable product and he can haul it at his convenience.

The accompanying table shows that the greatest number of orchards are located about three miles from the nearest shipping point. The number of orchards outside of this zone grades away in both directions but more rapidly in the zones of greater distance. This table may not be entirely representative of actual conditions, since in spite of the efforts of the field men to distribute their visits evenly the more accessible orchards were naturally visited in greater numbers. It does show, however, that there are many orchards located some little distance from shipping points and that the prune grower is finding it possible to make a living at some distance from the railroad where land is cheaper. Probably the future tendency away from town will be more marked as the price of land close to town rises.

TABLE III.

Miles	1	2	3	4	5	6-7	8-10	11-15	16-20	Over 20	Total
COUNTY.	Number of Orchards.										
Douglas	38	25	26	11	7	19	20	7	2	......	155
Lane	5	11	12	4	6	7	......	......	......	......	45
Wasco	12	5	3	1	1	......	......	......	......	......	22
Umatilla	8	5	6	4	7	7	1	......	......	......	38
Union	14	1	1	......	......	......	......	......	......	......	16
Yamhill	26	28	27	3	1	......	......	......	......	......	85
Marion	8	5	21	31	22	34	3	......	2	......	126
Polk	11	19	25	7	......	......	......	......	......	......	62
Washington	2	9	5	1	1	1	8	......	......	......	27
Total	124	108	126	62	45	68	32	7	4	......	576

Some investigation was made of the cost of certain operations in orchards close to town and in orchards at a distance. An inquiry into the cost of picking, which is sometimes said to be greater away from the towns, showed that there is little or no relation between the distance from shipping point or town and the cost of picking. The variation in price is governed more by the nature of the community and by the number of women and children in it.

Exposures.

In a state with such diversity of conditions as exists in Oregon a considerable variation in suitable exposures is to be expected. In the southern part of the state the level lands of the river bottoms are generally the most desirable sites and are the most frequently chosen. Southerly slopes of any magnitude are generally avoided because of shallow soil and lack of moisture. At the same time the orchards on the bottom land suffer more from spring frosts. This holds true as far north as Lane and Benton counties. In Lane county most of the orchards are on river bottoms. From Marion and Polk counties north less care is exercised and southerly slopes seem to do as well as any other. Most of the orchards in this region are on rolling valley or hill land.

In Wasco county all the prune orchards are located on the hills with little regard to slope; one slope is apparently as good as another. Umatilla county prunes are produced mostly on river bottom lands largely because of their availability for irrigation. In Union county there appears to be little choice between the various slopes; a large share of the prunes grown in this county, however, are raised on the more level lands.

TABLE IV.

COUNTY.	N.	N. W.	W.	S. W.	S.	S. E.	E.	N. E.	Level.	More than one slope.
	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.
Douglas	185.0	108.0	108.75	22.5	160.75	180.5	202.5	6.0	1276.55	....
Lane	36.5	2.0	6.0	....	....	....	12.0	1.0	490.0	....
Wasco	19.5	....	3.0	22.5	34.5	....	1.0	10.5	8.5	56.6
Umatilla	....	....	....	....	....	....	....	....	180.8	....
Union	....	....	79.0	....	....	....	....	....	41.5	....
Yamhill	28.0	20.0	212.0	30.5	406.0	120.75	354.75	87.5	181.5	16.7
Marion	346.0	75.0	390.25	69.0	220.0	63.0	324.5	57.5	71.5	782.25
Polk	348.25	30.0	170.0	40.5	165.0	34.5	130.75	15.0	58.5	45.0
Washington	21.0	22.0	42.0	12.0	63.5	24.0	125.0	....	....	29.0
Total	948.25	257.0	1011.0	197.0	1049.75	422.75	1150.5	177.5	2308.85	1079.75

Size of Orchards.

As is to be expected, the small orchards are the most numerous. It is worthy of note, however, that the total area in orchards of from one to five

acres is exceeded by that of from six to 10 acres, is equalled by that of orchards of from 11 to 15 acres, and is very nearly equalled by that of orchards of from 16 to 20 acres.

By far the greatest number of the small orchards are adjuncts to general farming, rather than part of a system of growing several kinds of fruit. Some of these orchards receive the best of care but many are badly neglected. There are more poor orchards in this class than in any other.

It is not till the 11 to 15 acre class is reached that there are any number of places on which a large part of the income is derived from prunes. Even in this class the number is not great, but with larger acreages it is the usual case. It may be significant that in comparatively few cases is there any other fruit grown commercially on places where there are prune orchards.

Soils.

Because of the impossibility of securing accurate figures in enough instances, no attempt was made to correlate soils and yields. A mere statement of the number of orchards found on the different soil types would be of little value; hence no tables are presented bearing on soils. Some general statements can be made with certainty.

The prune will thrive on a greater variety of soils than will any other orchard fruit. On very heavy soils it will not do so well as the pear, nor on the very light soils, so well as the peach; but it will thrive on more kinds of soil than will either of these.

Fig. 3. Spraying prunes in winter.

Participation in the controversy between "hill men" and "valley men" is unnecessary here. Both hill and valley lands have their advantages and their disadvantages. The river bottom and rolling valley soils probably produce somewhat larger yields and slightly larger fruit, other conditions being equal, than the hill soils. On the other hand, many of the valley lands are in sad need of drainage, and frost injury is much more likely to occur. Trees on the hills sometimes need a little extra thinning out in pruning to insure larger sized fruit, and the fruit they bear may dry a little heavier.

Good soil does not free the grower from the necessity of caring for his orchard. Some of the poorest orchards are on the best land, conversely some of

the best orchards are on land that is naturally poor. Good drainage and careful cultivation are the most important considerations as far as soil is concerned.

Planting—Rectangular System.

TABLE V.

Distances of Planting	16 x 16		18 x 18		20 x 20		24 x 24		Total	
COUNTY.	Orchards Reporting.	Acres.	Orchards Reporting.	Acres.	Orchards Reporting.	Acres.	Orchards Reporting.	Acres.	Orchards Reporting.	Acres.
Douglas	9	80.0	34	482.8	59	740.5	1	18.0	103	1321.3
Lane	11	50.0	13	73.0	11	201.0	......	....	35	324.0
Wasco	6	16.5	......	....	10	97.5	2	16.5	16	114.0
Umatilla	11	97.0	2	9.55	13	38.25	......	....	26	144.8
Union	4	25.0	3	8.0	2	64.5	......	....	9	97.5
Yamhill	10	125.5	23	248.5	22	729.75	3	77.0	58	1180.75
Marion	10	95.75	28	314.5	74	1516.5	......	....	112	1926.75
Washington	8	44.5	12	116.0	9	128.0	......	....	30	296.5
Polk	18	301.5	17	144.5	25	421.0	......	....	61	897.0
Total	87	835.75	132	1396.85	225	3937.0	6	111.5	452	6317.1
Miscellaneous distances	......	....	......	....	......	....	......	....	53	547.0

"Miscellaneous distances" includes orchards with trees planted at the following distances apart:

12 x 12   14 x 14   16 x 17   15 x 20   16 x 32   17 x 17   20 x 24   27 x 27
12 x 18   15 x 15   16 x 18   16 x 20   16½x 16½   17½x 17½   21 x 21   30 x 30
12 x 30   15 x 16   16 x 19½   16 x 24   16½x 20   18 x 20   22 x 22

Planting—Hexagonal System.

TABLE V—Continued.

Distances of Planting	16 x 16		18 x 18		20 x 20		Total	
COUNTY.	Orchards Reporting.	Acres.	Orchards Reporting.	Acres.	Orchards Reporting.	Acres.	Orchards Reporting.	Acres.
Douglas	2	27.0	2	19.0	21	270.0	25	316.0
Lane	2	18.0	5	118.0	2	55.5	9	191.5
Wasco	......	....	......	....	......	....	......	....
Umatilla	......	....	......	....	......	....	......	....
Union	......	....	......	....	......	....	......	....
Yamhill	1	25.0	1	3.0	3	49.5	5	97.5
Marion	......	....	1	77.0	1	29.5	2	106.5
Washington	......	....	......	....	......	....	......	....
Polk	2	24.0	2	22.0	3	27.5	7	73.5
Total	7	94.0	11	239.0	30	432.0	48	761.0

"Miscellaneous distances" includes orchards with trees planted at the following distances:

14 x 20   16 x 18   17½x 17½   18 x 20   19 x 19   21 x 21   23½x 23½   32 x 32
15 x 15   16 x 20   17 x 22   18 x 24   20 x 22   22 x 22   25 x 25

The square system is by far the most common method, and 20 feet the most common distance for planting prune trees. Most of the very close planting found was in the older orchards; the general tendency where experience was accumulated is toward a liberal allowance of room for each tree. Time has clearly shown that an Italian prune in land that is worth cultivating will require a distance of fully 20 feet each way between trees. In the richer soils where the trees grow larger an allowance of 22 feet is desirable.

brush that the fruit is small; a more even distribution of the main branches permits a thinning out of the finer wood or brush without sacrificing the whole crop. Indeed the virtual thinning thus made probably increases the aggregate yield. This is the only thinning given the prune. Trees on hill lands are generally thinned a little more heavily to secure the proper size of the fruit. Old wood runs out, producing small prunes in small quantities.

Fig. 4. An Italian prune tree showing a lack of vigor.

A continual supply of new bearing wood is to be sought; when the tree is confined to two or three spindling main branches this renewal of bearing wood can hardly be secured except at the cost of an interruption in the bearing. A moderate amount of sucker growth is to be regarded as beneficial rather than detrimental, since it may be utilized in forming new bearing branches. In some trees that have been unpruned for some time the old wood has stopped bearing anything but a few undersized prunes but the branches that were suckers a few years back are now bearing the only good fruit.

Another common, but questionable practice is the lopping off of all fruit bearing wood that can be reached from the ground. This is proper, of course, in so far as it removes the spurs likely to interfere with cultivation or to be injured by it, but there is frequently room for a small amount of bearing wood on the inside of the main branches within easy reach of the ground.

The Petite needs more pruning than the Italian, a fact that is generally recognized. The tree is more inclined to become dense than the Italian, and less inclined to the spreading habit of this variety; the fruit does not thin itself naturally, however, and even when well grown is small. All these facts point to the need of thinning out rather than heading back for the Petite.

Cultivation.

The prune orchards of the state are in general better cultivated than they are pruned. There is practical unanimity of opinion as to the value of

cultivation; the widest diversity is found in the period at which cultivation is stopped. Some growers stop cultivation by the first of June, others continue it till the time of picking, leaving a soft bed of earth on which the prunes may drop without injury. This diversity of practice is generally based on good reasons, involving such factors as the nature of the soil and subsoil, drainage, exposure and depth of soil. The fitting of practice to conditions is generally intelligent.

In Douglas county there is a tendency to use the clod masher to finish each cultivation, leaving the soil packed on the surface and thus defeating the primary object of cultivation—the retention of moisture. Plowing is usually done early enough but subsequent operations are frequently delayed until the soil has dried out to an unnecessary and harmful degree.

Some of the Willamette Valley growers overdo cultivation and keep their trees growing too late. Ordinarily this may seem to do no harm, but in an unusually cold winter trees thus treated suffer badly from winter injury. This may also have some relation to the occasional failure of the ripe fruit to drop.

In Eastern Oregon cultivation has not been as careful as in the western part of the state. This may be due in some cases to the stony nature of the ground, but in many instances there has been too much reliance on irrigation to do everything but pick the fruit. The difference between results obtained with clean culture and those obtained with irrigation alone is very apparent in color of foliage, growth of new wood and yield of fruit.

The details of cultivation vary, naturally, with the location. The majority of the orchards are plowed at least once in three years; some are plowed annually, some in alternate years, some every third year. When the orchards are not plowed annually the disk harrow is almost invariably used in place of the plow.

The alternation of plow and harrow to break ground works very well except on the heavier land where the soil runs together during the winter and requires plowing every spring to break it up to a sufficient depth. The use of other common tillage implements varies with the soil. The Kimball weeder is a very general favorite on weedy soils, the Brillion roller on the heavier cloddy soil. The spike tooth or smoothing harrow is not fully appreciated by many growers; it is an excellent implement to follow the clod masher or other tools in finishing a cultivation.

Many growers prefer to leave a small space around the tree when culti-

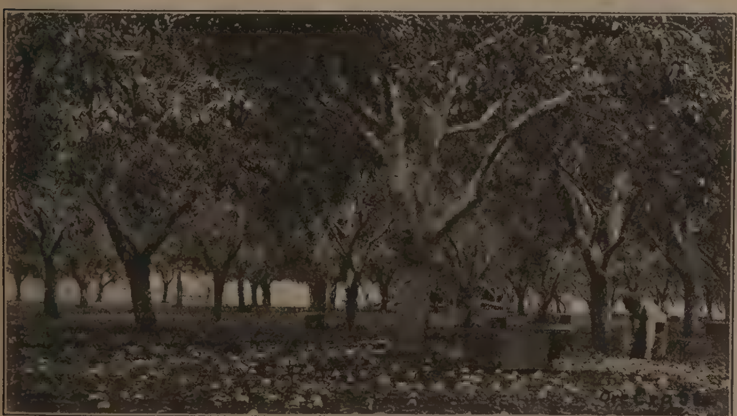

Fig. 5. Picking prunes for drying.

brush that the fruit is small; a more even distribution of the main branches permits a thinning out of the finer wood or brush without sacrificing the whole crop. Indeed the virtual thinning thus made probably increases the aggregate yield. This is the only thinning given the prune. Trees on hill lands are generally thinned a little more heavily to secure the proper size of the fruit. Old wood runs out, producing small prunes in small quantities.

Fig. 4. An Italian prune tree showing a lack of vigor.

A continual supply of new bearing wood is to be sought; when the tree is confined to two or three spindling main branches this renewal of bearing wood can hardly be secured except at the cost of an interruption in the bearing. A moderate amount of sucker growth is to be regarded as beneficial rather than detrimental, since it may be utilized in forming new bearing branches. In some trees that have been unpruned for some time the old wood has stopped bearing anything but a few undersized prunes but the branches that were suckers a few years back are now bearing the only good fruit.

Another common, but questionable practice is the lopping off of all fruit bearing wood that can be reached from the ground. This is proper, of course, in so far as it removes the spurs likely to interfere with cultivation or to be injured by it, but there is frequently room for a small amount of bearing wood on the inside of the main branches within easy reach of the ground.

The Petite needs more pruning than the Italian, a fact that is generally recognized. The tree is more inclined to become dense than the Italian, and less inclined to the spreading habit of this variety; the fruit does not thin itself naturally, however, and even when well grown is small. All these facts point to the need of thinning out rather than heading back for the Petite.

Cultivation.

The prune orchards of the state are in general better cultivated than they are pruned. There is practical unanimity of opinion as to the value of

cultivation; the widest diversity is found in the period at which cultivation is stopped. Some growers stop cultivation by the first of June, others continue it till the time of picking, leaving a soft bed of earth on which the prunes may drop without injury. This diversity of practice is generally based on good reasons, involving such factors as the nature of the soil and subsoil, drainage, exposure and depth of soil. The fitting of practice to conditions is generally intelligent.

In Douglas county there is a tendency to use the clod masher to finish each cultivation, leaving the soil packed on the surface and thus defeating the primary object of cultivation—the retention of moisture. Plowing is usually done early enough but subsequent operations are frequently delayed until the soil has dried out to an unnecessary and harmful degree.

Some of the Willamette Valley growers overdo cultivation and keep their trees growing too late. Ordinarily this may seem to do no harm, but in an unusually cold winter trees thus treated suffer badly from winter injury. This may also have some relation to the occasional failure of the ripe fruit to drop.

In Eastern Oregon cultivation has not been as careful as in the western part of the state. This may be due in some cases to the stony nature of the ground, but in many instances there has been too much reliance on irrigation to do everything but pick the fruit. The difference between results obtained with clean culture and those obtained with irrigation alone is very apparent in color of foliage, growth of new wood and yield of fruit.

The details of cultivation vary, naturally, with the location. The majority of the orchards are plowed at least once in three years; some are plowed annually, some in alternate years, some every third year. When the orchards are not plowed annually the disk harrow is almost invariably used in place of the plow.

The alternation of plow and harrow to break ground works very well except on the heavier land where the soil runs together during the winter and requires plowing every spring to break it up to a sufficient depth. The use of other common tillage implements varies with the soil. The Kimball weeder is a very general favorite on weedy soils, the Brillion roller on the heavier cloddy soil. The spike tooth or smoothing harrow is not fully appreciated by many growers; it is an excellent implement to follow the clod masher or other tools in finishing a cultivation.

Many growers prefer to leave a small space around the tree when culti-

Fig. 5. Picking prunes for drying.

vating, thus making sure that there will be no injury from cultivation. This space is later hoed by hand at a labor cost of from 25 to 50 cents per acre.

Some of the less careful growers are inclined to neglect cultivation in years when the orchard bears a light crop. In some few cases this tendency extends to entire omission of cultivation for the year. This is, perhaps, rather natural, but it should be severely condemned. The omission of one year's care sets the trees back for several years. The orchard needs as good care when it is bearing a light crop as when it is bearing its heaviest.

Cover Crops.

TABLE VI.

(Figures refer to the number of orchards reporting.)

COUNTY.	None.	Vetch.	Vetch and Oats.	Vetch and Rye.	Other crops.
Douglas	116	13	16	....	2
Lane	31	3	7	....	1
Wasco	17	....	2	....	....
Umatilla	27	....	11	....	....
Union	14	....	1	....	....
Yamhill	48	20	8	2	3
Marion	81	33	....	2	6
Polk	53	5	1	....	3
Washington	11	14	....	2	1
Total	398	88	46	6	16

Sixty-seven orchardists expressed the intention of sowing a cover crop during the fall of 1911.

In Table VI orchards in which cover crops have been used only occasionally are listed among those where they are used more often. In some cases only one crop has been used. A significant fact, not brought out in the tables, is that green manuring in prune orchards is a comparatively new practice. Few orchards have had cover crops more than five years; in the majority of those now reporting them it is only within the last year or two that the practice has been tried.

With very few exceptions those who have tried cover cropping are well satisfied with the results. There are a few who complain that the cover crop delays plowing so long that the ground becomes too dry and cloddy. It is probable that these men have waited till too late before plowing, trying to get a very heavy growth to turn under. In other cases the trouble is due to delaying the sowing of the crop too long. The very fact that the ground becomes cloddy is in part an indication of the need of humus. If the first crop is plowed in rather early it is probable that the succeeding crop can be plowed in somewhat later and the inclination to cloddiness will become less with each succeeding crop turned under.

The importance of getting the cover crop started early should be understood by prune growers. The majority of those who use cover crops in prune orchards wait until the prune crop is harvested before sowing. As this generally delays the seeding until well into October, the crop gets very little start before winter sets in. Thus handicapped, the crop starts in the spring with a small growth and before it reaches good size the best time for plowing is past. A cover crop drilled in before harvesting will not be materially disturbed by the operations of the pickers, neither will it interfere with the picking of the crop. At the same time it is getting started; it will go into the winter much further advanced than a later sown crop and may be plowed under earlier in the spring.

Drilling the seed in gives much better results than broadcasting. The seed is dropped deep enough to get the benefit of the moisture in the soil and is not entirely dependent on fall rains for germination. Indeed, a crop that

has been drilled in will in many cases have germinated before the fall rains begin. The per cent of germination, moreover, is likely to be greater.

Attention to cover crops is to be urged upon every prune grower. Their use is not necessary in every case or even advisable in some instances, but in many others it is to be strongly recommended. Continued cultivation is diminishing the humus in the soil. Soil fertility is a question that is bound to force itself on many prune growers; in fact, it is doing so even now and cover cropping is an important factor in soil fertility.

Fertilizers.

Barnyard manure is almost the only fertilizer applied to prune orchards. Its use is reported in Douglas county in 23 orchards; in Lane, seven; in Marion, 50; in Polk, six; in Yamhill, 30; in Washington, 12. By no means do all of the trees in these orchards receive manure annually; usually only a very small part can receive it in any year, because very few farms produce enough manure to cover the whole orchard, and very few cases were found where manure was brought from sources other than the farm itself.

The use of wood ashes was reported in six orchards. Land plaster has been used in two orchards. Other chemical fertilizers were applied in several cases but no results were reported. Lime was tried in one case with no result.

Because of the method of conducting these trials no information of any value, one way or the other, could be secured concerning the worth of chemical fertilizers.

As is suggested in the discussion of cover crops, the fertility question is likely to become one of importance, especially where the orchards were established on land long used previously for grain growing. It is only after careful study that the grower comes to a realization of the tremendous drain on the soil made by a crop of prunes.

Though barnyard manure is probably the best fertilizer, some other source of fertility must be sought, because enough manure is not available. Its nature and effect may be imitated closely by the use of cover crops, mainly for the amelioration of the physical condition of the soil, and of chemical fertilizers for the improvement of the chemical composition.

The use of chemical fertilizers is entirely new to most farmers in the northwest. There is no doubt that the use of some of these fertilizers would benefit many orchards. Each man should determine for himself, however, the needs of his own soil, rather than use a complete fertilizer of which some ingredients, though beneficial elsewhere, may do absolutely no good in his soil. The Division of Horticulture of the Experiment Station will gladly confer with any grower who wishes to make some trials of fertilizers and will, if he wishes, outline the work in such a way that he can determine for himself just what particular elements are needed in his orchard.

Fungous Diseases.

TABLE VII.

COUNTY.	Total Orchards.	None.	Brown Rot.	Root Rot.
Douglas	64	39	21	2
Lane	21	13	6	....
Marion	110	42	42	22
Polk	62	39	10	16
Washington	27	14	11	5
Yamhill	70	17	50	17
Total	354	164	140	62

The accompanying table shows in a rough way the prevalence of fungous diseases in the prune orchards in various regions of the state. It is open to the same objections that would characterize certain other reports, namely,

the lack of an arbitrary standard by which the presence or absence of a disease could be judged. Because of this fact, it is probable that some orchards which are very lightly infested, with brown rot, for instance, were reported by observant owners and thus classed among the infested orchards, while others, much more heavily affected, were reported by careless owners as free from disease. Disorders such as sunscald, sour sap, gummosis, "frost scab," etc., are not tabulated. Some of these are found to a greater or less extent in nearly every orchard, but are not always recognized. Their attack is slower and more insidious. The loss from such injuries is probably greater than that from any fungous disease. In some instances growers assured the observers that there was no brown rot in the orchard when a very slight search revealed it in considerable quantity. In such cases growers had not considered it a fungous disease but had merely dismissed it as a "mold."

The larger percentage of brown rot reported in some counties may be in part due to the fact that these orchards were visited in the fall when brown rot is noticeable and in an unusually rainy season. The fact that the fruit is picked rather early in the counties which ship green fruit east in considerable quantities, probably accounts in part, for the lack of brown rot infestations, though, of course, climate is also a factor. Brown rot is rarely of enough importance to justify summer spraying with Bordeaux. In this connection it is interesting to note that most of the growers who have long been engaged in prune growing report that the damage from brown rot has diminished greatly since they began systematic winter spraying. It varies from season to season, is worse in trees where the branches are thick and the sunlight is excluded and where the fruit hangs in clusters. Sugar and Silver prunes seem to be most seriously affected.

Fig. 6. A small house for packing "green" prunes.

Damage from the root rot or shoe string fungus varies in intensity and extent. Apparently several years are required to kill the tree. Both young and old trees are affected by it. It is found most commonly on land that was cleared shortly before planting to fruit trees and it occurs on land occupied formerly by both oak and fir, perhaps more commonly on the old oak grub land. The extent of infestation varies from one or two scattered trees in an orchard to one instance in which 2,000 trees were reported as having been killed by this disease. New land should be cleared very thoroughly before fruit trees are set.

Sunscald is found in practically every orchard. It occurs usually on the trunk, but may sometimes be found on the lower part of the branches, and is characterized by the killing of the bark on the southwest side of the tree. It is probable that the original damage is done when the tree is young and the injury may be covered by the healing tissues, or the decay of the injured wood may spread as the tree grows, resulting in the hollow trunks sometimes seen, or even in the final overthrow of the tree. Sometimes the injury appears on the north side of the trees, a fact leading to the conclusion that some other agency must have been active; but close examination of the grain of the wood will frequently show that the tree has gradually twisted around so that the dead tissue takes a spiral course from the ground to the first branches.

Sour sap is a condition more difficult to define, or indeed, to dissociate from winter injury. Areas of dead bark of varying sizes are found on all parts of the trunks. In these areas when the injury is comparatively recent distended vessels full of a brownish rather granular mass are common. With the passing of time, if the injury is slight, the trouble is manifest only in the area of dead tissue around which the healthy tissue is growing. This trouble seems to be confined almost wholly to young trees three to seven years of age. In these it is at times serious. Indeed, it is probable that sunscald and sour sap kill more prune trees than all the organic pests, insects and fungous diseases combined.

"Little prune," a condition where the fruit appears normal in every respect but size, in which it is notably, even ridiculously, deficient, appears in but very few orchards, and in these only in spots. No cause can at present be indicated for this trouble.

Gummosis appears frequently, but is rarely severe enough to cause any noticeable damage; lichens or "moss" are common, especially in orchards where spraying is neglected. Sometimes the lime-sulphur fails to eradicate them, but where thorough spraying is given every winter there is little trouble.

A roughening of the skin appearing early in the season but showing most prominently in the dried fruit is very common. In some orchards the amount of fruit thus affected in 1911 was as high as 15 per cent. In years when prunes were plentiful this kind of fruit would probably be rejected, but in 1911 it regularly went to the market, sometimes separately, sometimes mixed with the other prunes. Various causes have been advanced for this trouble. Some have attributed it to chafing by the leaves, some have attributed it to frost, some have even thought it to be a fungus disease. The most plausible suggestion, however, seems to be that it is due to the effects of frosts or cold rains very shortly after the setting of the fruit.

Insects.

Peach borers are to be found in a larger part of the prune orchards, probably in more orchards than the tables show. They appear to work as much on the trees on plum roots as on those on peach; the point where they work is above the union of stock with scion. Some growers report the borers worse

TABLE VIII.

COUNTY.	None.	San Jose Scale.	Peach Borer.	Twig Borer.	Aphis.	Other Insects.	Total No. of Orchards Reporting.
Douglas	52	42	38	6	15	35	155
Lane	16	14	24		2	1	45
Wasco	14	3	1				22
Umatilla	18	2	7			7	41
Union	2	1	3			10	16
Yamhill	27	14	42	3	[illegible]	12	85
Marion	15	14	108	30	28	49	126
Polk	5	12	55	7	10	9	62
Washington	3	5	8	5	4	18	27
Total	152	107	286	51	66	141	580

on young trees; but there are plenty on the older trees. In many cases growers dig them out, a few use some spray, lime-sulphur residue or various noxious substances as repellants. Some claim that leaving the ground hard and uncultivated for a foot or two around the tree tends to keep the borers out; this method, however, is of doubtful value.

Scale infestation has diminished to a small fraction of its original extent since spraying with lime-sulphur commenced. Where scale is reported, it is usually present only in very small numbers. Injury from green aphids appears to be increasing. In many cases they appeared in 1911 for the first time in the prune orchards; in practically all cases their presence in prunes was very recent. Most growers report them as less virulent on prunes, however. than on apples and cherries. They are much more frequently found on young trees, and in several instances were reported as worse on Petites than on Italians. Red Spider was found in a very few cases.

The shot hole borers are restricted to a few regions but are common within these limits. Many growers have become considerably worried by them and have gone to considerable trouble, either in digging them out, or in fighting them with Oil of Mustard injected into their burrows. Some claim that they will attack healthy trees; indeed, in one or two instances the observer was unable to find any signs of weakness or disease in infested trees. In nearly all cases, however, careful search revealed some previous injury to affected trees. Usually this was due to sunscald, sour sap or winter injury.

Certain rodents are more injurious in some localities than are the insects. Squirrels, rabbits and gophers sometimes kill large numbers of young trees. Carbolineum has been tried as a repellant, but with varying success, sometimes protecting the trees and sometimes killing them. Other repellant substances and mechanical protectors, as well as poisoned grain and vegetables, have been tried, but the results as reported are far from uniform.

Spraying.

Spraying practice among prune growers throughout the state is fairly uniform. It is confined for the most part to a single winter application of lime-sulphur. The principal methods are indicated in the accompanying table. Though there is almost unanimous opinion as to the method and materials, there is great diversity in the details of execution. For instance, some growers spray as soon as the leaves drop in the fall, while others wait till the leaves begin to push out in the spring, and a few spray twice during the winter. The dilution of the stock solution varies between 1 to 6½ and 1 to 20; the amount of spray used per tree in mature orchards varies from one to five gallons, with two gallons the usual allowance. Few growers use the Baume hydrometer.

Some departures from the orthodox methods in spraying may be found. A few growers, apparently thinking that if a little is good more is better, either mix complete Bordeaux with the lime-sulphur or add copper sulphate (blue stone or blue vitriol) alone. There is no definite reasoning back of this practice and no probable gain; very likely a loss. A very few report the use of caustic soda in water, while distilled fir, whitewash, etc., are occasionally used. One grower reports the use of one quart of kerosene to every 50 gallons of lime-sulphur. Twenty pounds of lime with half a pound of lye to 50 gallons of water is another combination used by one grower.

A few orchards receive more or less summer spraying, mostly with some of the tobacco compounds; but in perhaps four or five cases, with arsenate of lead for the twig borers. In some cases the arsenate is applied with the lime-sulphur just as the leaves burst forth in the spring. Whale oil soap and quassia chips are used for aphids in one Polk county orchard.

The table shows several interesting facts, of which the most important is that the smaller orchards, as far as concerns spraying, at least, receive more care than the larger. There is a slight difference in the average sizes of orchards using home-made lime-sulphur and those using prepared, but it is not significant. The average size of orchards using hand outfits is 11.9 acres, that for orchards using power outfits is 25.6 acres.

The following facts should be added: (1) That many, probably most, of

Spraying.

TABLE IX.

County.	Season.								Material.				Outfit.			
	Annual.		Alternate.		3 yrs. or more.		Unsprayed.		Home-made.		Commercial.		Hand.		Power.	
	Orch.	Acres.	Orch.	Acres.	Orch.	Acres.	Orch.	Acres.	Orch.	Acres.	Orch.	Acres.	Orch.	Acres.	Orch.	Acres.
Douglas........	91	981.3	41	909.0	14	151.0	10	69.0	12	206.5	73	1210.8	96	1063.3	31	766.0
Lane...........	28	294.5	3	16.0	6	197.0	5	26.0	3	74.5	30	357.0	24	143.5	9	313.0
Wasco..........	12	114.0	2	8.0	1	4.5	7	32.0	....	....	15	126.5	13	118.0	1	3.0
Umatilla.......	19	113.75	4	9.5	8	12.5	11	45.05	....	....	20	121.75	15	95.75	3	14.25
Union..........	2	7.0	....	....	3	10.5	11	106.5	1	5.0	4	12.5	2	7.0	....	....
Yamhill........	46	525.75	13	204.25	19	695.25	6	91.5	9	304.0	9	107.0	13	196.5	....	....
Marion.........	46	645.75	29	713.5	30	559.25	20	481.0	7	157.0	58	1259.25	48	693.0	25	753.0
Polk...........	18	252.5	4	101.0	15	252.8	25	454.25	3	25.0	18	396.5	20	347.0	6	145.0
Washington....	17	240.5	5	54.0	5	44.0	....	....	8	101.5	9	106.0	13	117.0	10	209.0
Total......	279	3175 15	101	2015.25	101	1926.8	95	1305.3	43	923.5	236	3797.3	244	2781.05	85	2203.25
Average Size....		11.3		19.8		19.7		13.7		21.5		16.1		11.3		25.9

the unsprayed orchards are not yet in bearing; (2) that the choice between home-made and prepared lime-sulphur depends more on accessibility to a cheap source of prepared stock solution, such as a local Fruit Growers' Union, than on the size of the orchard; (3) that some of the small orchards reporting the use of home-made lime-sulphur and power sprayers, usually associated with large orchards, are only parts of ranches having other kinds of fruit, so that in consequence the differences in the last two comparisons are in reality greater than shown by the table. This fact is also somewhat obscured in the table because many of the larger orchards reporting the use of hand power outfits are only partly sprayed each year, the whole orchard being covered once in two or three years.

"Green" or Fresh Prunes.

A more or less comprehensive survey was made of the "green" prune industry of Oregon. This included a study of methods of harvesting, packing and shipping as well as the kind of fruit desired by the consumer. At present the returns would indicate that in a very few years the shipment of prunes in the "green" or fresh state, will be largely, if not entirely, confined to the eastern part of the state, where the average rainfall is rather low. There have been several attempts to ship prunes green from different sections of Western Oregon, but in most cases the returns have been unsatisfactory.

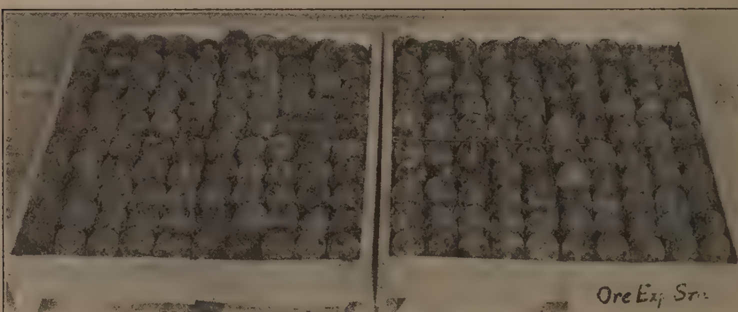

Fig. 7. A "5 x 5" prune pack.

In order to ascertain what the "trade" thought of the different varieties of prunes and of the same varieties from the different sections of the state, a large number of letters were sent out to commission firms in the larger cities in the different sections of the United States. The similarity of the replies was so striking that we feel justified in drawing some few conclusions from them.

The Italian prune is considered as Oregon's best seller; the Tennant, Hungarian, Pacific and Tragedy are mentioned, however, as varieties with promising qualities. Only a few of each variety are being grown. A prune with the flavor and quality of the Italian, and ripening two weeks earlier, would be very desirable for shipping fresh. The Italian prunes from Eastern Oregon and Idaho hold up better in transit than those from Western Oregon, especially from the Willamette Valley, since the prunes from the latter locality are sometimes started to market in poor condition.

The industry is comparatively new in Western Oregon, and the condition of the prunes when they reach the consumer may be due largely to improper handling and packing. In fact, one of the writers has seen many prunes going into the crates in a Willamette Valley packing house that would have been discarded entirely in other sections of the state. There is considerable evi-

dence on the other hand that prunes from this region are somewhat softer than those from Eastern Oregon. In view of such facts it would seem advisable for the growers of the Willamette Valley and other parts of Western Oregon to confine their efforts to the production of evaporated prunes, or to make radical improvements in their methods of handling, grading and packing.

Prunes that are to be shipped fresh should be hand picked from the tree from two weeks to a month in advance of those used for drying, and should be handled very carefully and rapidly. They will have attained full size and very nearly full color, but are still green and solid. For packing, four basket crates are used, each crate holding about 25 pounds. The packing is mostly done by girls and women who receive from four to six cents per crate. The packers are required to sort as they pack, discarding all soft or injured prunes and grading into the sizes designated as follows: 4x5, 5x5, 5x6 and 6x6. The majority fall in the sizes 5x5 and 5x6. These sizes are so named from the number of prunes in a row each way in the basket. In the more successful districts the prunes are packed at an association packing house, if possible, and when the crop is too heavy to be handled that way, some of the growers pack their fruit at the orchard, merely shipping it through the union. In either case there is a very rigid inspection maintained. This is very important, as the fruit breaks down so rapidly that over ripe and injured prunes must be discarded. The covers should fit closely, in order that there may be no loose prunes. Refrigerator or ordinary freight cars may be used for shipping, loaded with 1,000 crates per car.

Green prunes sell for various prices, depending on the size of the crop and the quality of the fruit. The prices range from 50 cents to $1.25 per crate, which means a net profit to the grower of 50 cents to $1.00 per bushel. The cost of crates, packing, paper, and loading on the car, is placed at 20 cents per crate. An additional profit might be obtained by using a small dryer in connection with the packing house, in this way obtaining a profit from the culls and over ripe prunes which would otherwise be a complete loss.

This method of marketing prunes is very well adapted to the grower with an acreage too small to warrant the maintenance of a dryer. In such cases it would be necessary to secure, however, enough prunes to permit shipment in carload lots. Those small growers who are required to pay 2½ cents per pound for having their fruit dried could no doubt find relief by forming an association and shipping their product "green."

Picking for the Dryer.

Picking, which is one of the most important of all the operations involved in handling a prune crop, is frequently the one receiving the least attention. A common practice is to allow the pickers to shake the trees with a pole, or to send a strong man, however careless, through the orchard. This results in a considerable amount of unripe fruit going to the dryer. Another practice is to refrain entirely from shaking until the last picking, with the idea of harvesting only ripe fruit. The trouble with this method is that it results in a considerable amount of over-ripe prunes. In a time when fruit is ripening steadily, if there is no shaking of the tree at all, a considerable amount of fruit drops soon after the pickers have passed and is over-ripe before they get around again.

The practice as to the number of pickings varies to some extent, from one to 15 pickings per season being reported. By far the greatest number of growers report three pickings as their practice in the average season, with four the next most frequent number. There is a slight tendency toward a diminution in the number of pickings with the increase in size of the orchards, the average for the smallest being 3.5, for the largest 2.9.

As the average number of pickings varies, so does the amount of shaking, as before noted. Perhaps the most common method when three or more pickings are made, is to shake the trees at the last two. The greater the number of pickings, as a rule, the better will be the product, as it will tend more toward a uniform degree of ripeness. Through lack of labor, however, and through higher prices asked when pickings are more frequent, three or four is generally

the maximum number possible. In many cases no shaking at the first picking will be necessary. On the other hand, under peculiar climatic conditions, it may be advisable at times to shake all the prunes down at one time and save extra pickings. This condition was experienced in parts of the Willamette Valley this season. The crop was light and all ripened at the same time. It is hardly necessary to state that clubbing the fruit from the trees is bad practice. The shaking or jarring of the trees should be done by the most experienced and careful man available.

The Profitable Unit.

The table of "size of orchards" indicates that the average prune orchard is small. It is. But the small orchard is almost invariably only part of the income producing plant. The novice should not permit himself to be deluded into the idea of making a good living from five or ten acres. The prune lends itself peculiarly well to rather large acreages; a man growing prunes alone can handle 30 acres to better advantage than he can ten. With a small acreage there is too much unoccupied time for horses and man; the grower should consider himself as drawing wages to be paid out of the prune crop; he should consider his horses as so much capital invested, on which he would otherwise be drawing interest, and he should consider the feed he is giving them and count their idleness as loss to him. To stop these leaks in his financial management, the grower should have an acreage that will keep him and his equipment reasonably busy. For this reason 30 acres is a good unit.

A little reflection will show that it is possible for a 30 acre ranch to pay better than a somewhat larger place. For instance, 30 acres are assumed as keeping a man and horses busy. Forty-five acres would require another man and more horses, but would not keep the extra man and extra horses busy all the time. Thirty acres would involve less financial loss through idleness on the part of man or equipment.

The foregoing must not be interpreted as discouraging the planting of smaller orchards. When combined with other lines of fruit growing or general farming, the small prune orchard is often very profitable. It is these places that bring down the average size of orchards. The man contemplating the establishment or acquisition of a small prune orchard should realize, however, that there are some disadvantages in a small orchard. In the first place, the man having a small quantity of prunes to market is not likely to get as good prices as the man who is selling the product of a large orchard. In the second place, a small orchard will hardly warrant any extensive investment in a dryer, and without a dryer the man having prunes to market is at the mercy of those owning dryers. When the crop is ripening all at once, and the dryers are crowded, his fruit must wait its turn. It is a regrettable fact, moreover, that in certain localities in the state, the men owning dryers have at times combined to enforce an unreasonable charge for drying. This the man without a dryer cannot escape.

As a side line, however, the small orchard frequently works in very nicely. Other types of fruit growing or general farming may need something to fill in a little slack time; this want the small orchard often supplies. In this case the owner is not absolutely dependent on his prunes, and any profit represents so much clear gain. Ten acres of prunes have been found to be a good unit when combined with general farming.

In considering the best size for an orchard, the labor factor is frequently important. In this respect the prune has the advantage over other fruits, since less skilled labor is required in handling it. Only one spraying is given, no expert packers are necessary, no hand thinning is done, the picking is from the ground and is done mostly by women and children, and even at the dryer only part of the force must necessarily be skilled. All this means that there will be less difficulty in handling a large prune orchard than would be encountered with an equal area devoted to any other orchard fruit.

Intercropping.

Intercropping is generally understood to refer to the growing of small fruit or vegetable crops between young trees. It is resorted to in very few cases in prune orchards. This may be explained by the fact that few prune orchards are "promoted," as are the apple, pear and cherry orchards, where intercropping is most common. The young prune orchards are either large plantings backed by resources ample enough to keep them going till they reach the bearing stage, or they are mere adjuncts on places already self-supporting from other revenue. Under either of these conditions the incentive to intercropping is not very keen.

Grain is sometimes grown in the young orchard; in such cases a small strip is usually left on each side of the trees. This plan is generally accompanied by a failure to cultivate properly the unplanted strip. Grain growing in a young orchard of any kind is not to be recommended. Strawberries are occasionally grown to good advantage. Loganberries may be used but great caution is necessary in this case.

It would seem that potatoes could be grown to good advantage in the young orchards on reasonably level land. Owners of large properties are usually as anxious to reduce expenses as are the small holders. The potato is especially adapted to growing on a large scale with a minimum amount of labor. Potato planters and diggers are not very costly and the four of five crops harvested before the trees begin to bear would go far toward reducing expenses, and would in many cases turn in clear profits. The cropping might be continued, a little less aggressively, for a few years after the trees had begun bearing. The potato may be used for interplanting, though it, too, must be handled with care, because of its heavy drain on the potash of the soil.

Sometimes conditions are reversed, and the prune is used as a filler, for planting between other trees. This is most common in young walnut groves. In this combination the favorite plan puts one prune tree between every two walnut trees, making three prune trees to every walnut. It may be remarked in passing that two prune trees between every two walnuts, making eight prune trees to every walnut tree, would be better. If all the trees were set at 20 feet intervals, the walnuts, after the prune fillers were removed, would have 60 feet of space.

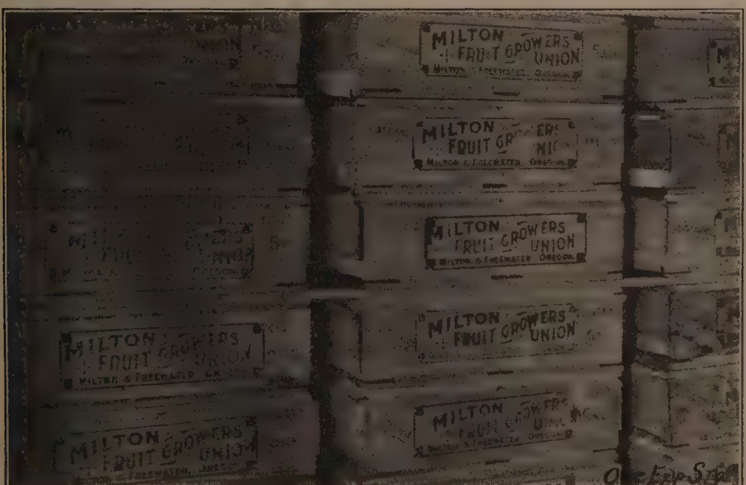

Fig. 8. Green prunes in a car; showing proper spacing and bracing.

may be materially increased. The orchards reporting the highest yields are not especially favored in location; the care given them is the main factor in raising them above the average.

Summary.

After a careful study of existing conditions as outlined above, the writers believe that the prune growing industry may be improved in three directions:

1. In growing the fruit to secure greater yields. Tillage may be improved in many orchards; pruning should receive more attention in most cases. Cover cropping would benefit a large proportion of the orchards as regards both the chemical composition and the physical condition of the soil.

2. In handling the fruit to secure a better product. This refers to the care in picking the prunes, to secure uniform ripeness, the proper drying of the fruit and a standardization of the finished product. Until some definite standard, chemical or otherwise, is adopted, the man who puts extra care into handling his crop and who culls it faithfully, is at a disadvantage as compared with the less careful or less scrupulous grower. Each man puts the blame for bad conditions on his neighbor and little progress is made toward improving the quality of the output. The processing and packing establishments have done much toward standardizing the product, but the growers must do more.

3. In promoting co-operation. This is a statement that cannot be made too strong. If no other reason could be urged, the possibility of securing a uniform output through co-operative associations would be enough in itself to justify their existence. Most of the prunes grown in this state are produced in communities where prune orchards are numerous; very few prune growers are so located that they could not belong to an association and market their crops through it.

The exact nature of the associations and the work they undertook would naturally vary with the locality and the membership. In some cases the association could even process the fruit, as is now done by the fruit growers at Scott's Mills, near Silverton. The buying of spraying materials and seeds and the drying of the fruit from the small orchards could be well handled by such associations. No small item is the exchange of ideas and experiences and the stimulus of friendly rivalry among the members. But above all is the standardization of the product. The public confidence in the goods behind the label is, after all, the main factor in selling northwestern apples; let it once be known that prunes from a certain association contain no bloaters or half mouldy fruit, that the association sends out a uniform good quality, and substantial recognition of the fact will not long be delayed. At present one man, no matter how good his intentions, is virtually powerless; his fruit, no matter how carefully prepared, is necessarily mixed at the processing establishment with fruit from less scrupulous growers, and the market gets fruit of only medium quality. The high prices received in 1911 were a misfortune to the prune industry, for they tempted people to market fruit that would ordinarily be thrown out, and when this fruit reached the consumer the demand slackened. One lot of bad prunes hurts every man in the business. Prunes are not absolutely essential to life, and the consumer after a few trials with poor prunes turns to something else. In self defense, therefore, to keep what they already have, if not to increase their gains, the growers should get together and establish definite grades other than size alone. The best, in fact almost the only, way to do this, is through co-operative associations.

FROST INVESTIGATION WORK OF 1912.

By C. I. Lewis and F. R. Brown.

The work this year consisted of testing different types of heaters and the study of thermometers and frost alarms. Some preliminary work was done in other lines, such as smudging and questions connected with it. This latter work, not being sufficiently conclusive, will be continued for another year before any report can be made.

The object of the experiments with the different types of heaters was to decide the value of each one under Oregon conditions. It was hoped that a heater could be found that would give greater efficiency than the Bolton heater, which is the one most commonly used in this state.

There has been a constant question with prune growers of the state whether the annual loss of prunes in the spring was due to cold rains, lack of pollination, or frosts.

To eliminate, if possible, one of those factors of loss, the work of orchard heating was conducted in a prune orchard located in a prune district.

The Orchard.

The orchard is located on the east bank of Cow creek, about a mile from the town of Riddle. It is composed of three separate tracts, one belonging to Mr. P. A. Wilson, containing eight acres; one belonging to Mr. J. B. Riddle, containing eight acres; and a third belonging to Mr. Ed. Hervey, containing 10 acres.

The land upon which the orchard was planted was practically level. The trees are mature and planted in squares 20 feet apart. The trees in the Wilson orchard are especially large.

The test plot was selected in Mr. Hervey's orchard for three reasons: First, that part of the orchard was known to be more often hurt by frosts than the rest; second, Mr. Hervey had not intended to smudge, so that more than half of the orchard could be left as a check; third, the soil conditions were the same throughout the plot, the trees uniform and conveniently located.

The trees in the test plot have a spread of 16 feet and average about 17 feet in height. They were thoroughly sprayed with lime-sulphur just before the buds opened and were in fair condition. The orchard, in fact, is a very good average of a large number of the orchards throughout the state, both in cultural conditions and vitality of the trees, so that any work done here would compare very favorably with that conducted in any other section in the state.

The orchard was practically in full bloom Saturday, March 30, although some of the flowers were still opening during the next five days. The weather during this period, on the whole, was very favorable for pollination, remaining warm and clear for several days, although a brisk wind blew a part of the time.

The minimum temperature for six days during the blooming time, taken three days before the date of full bloom and three days after, was 35 degrees, while the average minimum was 38 degrees. The maximum for the same time was 76 degrees, with the average maximum 66 degrees.

The heaters were arranged in blocks of half an acre each and were placed at the rate of 100 to the acre. When completed, the block consisted of four rows of 12 heaters of each type, the whole block heated being 16 rows wide and 24 rows long. The heaters were placed in a solid block and the outsides reinforced so that practically all were under the same conditions.

The first test that was made was carried on before the buds were out far enough to be in danger. Some crude oil was obtained which had a large per cent of water in it, and a test was made to find if possible a heater that would burn wet oil.

The heaters were all lighted and for half an hour burned very evenly; but at the end of that time the first ones lighted began to boil over.

The Bolton, National, Troutman, Hamilton Lard Pail and Hamilton Reservoir all boiled over and acted very much alike.

The rate at which the Hamilton heater boiled over depended on the size of the opening; the larger the opening the more quickly it boiled over. When the pots boiled over they frequently damaged the buds by scorching them. None of these types were adapted to such oil.

Fig. 9. Bolton Orchard Heater boiling over. A small quantity of water in the oil is the cause.

A second test was made with the regular smudge oil that gave almost exactly the same results, except that after boiling over the Hamilton Reservoir almost invariably went out.

The Ward Heaters did not boil over, although they were relighted three or four times, but it was found impossible to make them burn, as the steam collecting under the hoods exploded with such force as to extinguish the fire. With the lighter oil, however, they boiled over when only a small amount of water had collected in the bottom of the heater. When they did boil over, they burned so fiercely that some of the small branches were slightly scorched.

The Richardson Heater was not tried with the crude oil, as it was not adapted to that grade. By using the Richmond smudge oil it was found possible to burn wet oil; some of the heaters, in fact, were left uncovered during a very heavy rain and when they were lighted afterwards they burned with little difficulty. There was considerable sputtering and frying as the water ran out with the oil.

A Test for the Burning Time with a Measured Gallon.

On the morning of April 5, a light frost occurring, a test was carried out under actual frost conditions. The heaters had been supplied with a measured gallon of oil previous to this time.

The Richardson Heaters required a man to watch them for the first hour to keep them regulated and even under careful handling were very wasteful.

The Ward Heaters have five openings, each with a separate cover. With less than three openings burning the gas collects under the remaining covers and explodes with force sufficient to extinguish the fires. With three or four openings burning, the explosion of gas removes the remaining lids and consequently all five openings become ignited.

The National Heater is difficult to light quickly, much time being required to remove the covers; when once lighted, however, the heater requires very little additional attention.

The Bolton, Troutman and Hamilton Competition Heaters were each lighted in 10 minutes by one man and required no more attention.

The Hamilton three gallon reservoir required one man 15 minutes for each 16 heaters. The covers on this heater were very hard to open, some sticking very badly. Twelve of the heaters were opened to the first hole, 12 to the second hole and 24 to the fourth hole and after lighting required very little attention.

The burning time, time of lighting and number of men required can be seen by the accompanying table.

TABLE I.

Burning Time for a Measured Gallon.

Heater.	Lighted.	No. of Men.	Time to Light.	First Heater Out.	Last Heater Out.	Burning Time.
Richardson	2.30 a. m.	2	25 min.	4.30 a. m.	5.00 a. m.	2 hrs. 21 min.
†Ward	2.30 a. m.	1	15 min.	5.00 a. m.	6.15 a. m.	3 hrs. 23 min.
National	2.30 a. m.	1	15 min.	6.15 a. m.	8.30 a. m.	5 hrs. 15 min.
Bolton	2.25 a. m.	1	10 min.	5.30 a. m.	6.20 a. m.	3 hrs. 32 min.
†Troutman	2.45 a. m.	1	10 min.	6.15 a. m.	7.05 a. m.	3 hrs. 51 min.
†Hamilton Competition heater	2.15 a. m.	1	10 min.	5.15 a. m.	5.45 a. m.	3 hrs. 00
*Hamilton reservoir, 2d	2.25 a. m.	1	15 min.	5.20 a. m.	6.10 a. m.	4 hrs. 20 min.
*Hamilton reservoir, 3d	2.25 a. m.	1	15 min.	4.50 a. m.	5.35 a. m.	3 hrs. 50 min.
*Hamilton reservoir, 4th	2.15 a. m.	1	....	4.20 a. m.	5.20 a. m.	2 hrs. 35 min.

†Heaters left a heavy residue of $\frac{1}{8}$ to $\frac{1}{4}$ inch in bottom.

The Ward heaters are so constructed that they will leave a heavy residue each time. This is due largely to the fact that the burning area is too small for the amount of oil consumed.

*Open to the 2d, 3d and 4th hole in the order given.

TABLE II.

April 5, Temperatures When Burning a Measured Gallon.

Inside Temperatures.

Heater.	3.00	3.30	4.00	4.30	5.00	5.30	6.00	6.30	Increase. Highest	Increase. Average
Ward	33.0	33.0	33.0	35.0	35.0	......	......	......	....	....
	32.0	33.0	33.0	35.0	35.0	Most out			....	....
Increase	2.5	3.0	1.0	2.0	2.0	......	......	......	3.0	2.1
Richardson	32.0	33.0	34.0	35.0	34.0	......	......	......	....	....
	33.0	34.0	35.0	36.0	35.0	All out			....	....
Increase	2.5	3.5	2.5	2.5	1.5				3.5	2.5
Bolton	35.0	34.0	35.0	37.0	36.0	35.0			....	....
	34.0	35.0	35.0	36.0	36.0	35.0	All out		....	....
Increase	4.5	4.5	3.0	3.0	3.0	2.0			4.5	3.4
National	33.0	33.0	34.0	36.0	36.0	36.0	36.0	37.0	....	....
	32.0	32.0	34.0	37.0	36.0	36.0	37.0	37.0	....	....
Increase	2.5	2.5	2.0	3.5	3.0	3.0	3.5	3.0	3.5	2.87
Troutman	33.0	35.0	35.0	35.0	35.0	34.0	34.0	All out	....	....
	33.0	36.0	35.0	35.0	35.0	35.0	34.0		5.5	2.57
Increase	3.0	5.5	3.0	2.0	2.0	1.8	1.0			
50 Ward per acre	33.0	33.0	34.0	34.0	35.0				....	....
	32.0	34.0	34.0	34.0	35.0	All out			....	....
Increase	2.5	3.5	2.0	1.0	2.0				....	....
Outside temperatures	30.0	30.0	32.0	33.0	33.0	33.0	33.0	34.0	....	....
	30.0	30.0	32.0	33.0	33.0	33.0	33.0	34.0	....	....

It will be noted by this table that the average increase of Troutmans would have been a little higher but for the fact that they were only lighted a short time before the first reading was taken and the heaters had not yet reached their maximum burning.

The National Heaters kept the temperature two degrees above the outside temperature until after 7:00 but no readings were attempted after 6:30 for

the reason that the time was taken up noting or watching the other heaters, as they went out, and for the further reason that the sun was shining in the orchard and temperatures could not be taken as accurately. The outside temperature remained at 34 until after 7:00 a. m.

All the heaters were allowed to burn until they went out and an average was taken, considering the time when the first one went out, when the majority of them went out, and when the last one went out.

The cost of the oil per acre was $2.67; cost of lighting, 50 cents per acre; cost of filling, 50 cents per acre; total cost for the first burning amounted to $3.67 per acre.

A Test with 50 Heaters per Acre.

On April 14, another frost was expected, and it became necessary to light the heaters at about 2 o'clock, or shortly before, as the temperature had dropped below 32 degrees.

For all of the work this season the plan was carried out not to allow the temperature in the orchard to drop below 32 degrees, as no work had been done to determine at what temperature the young fruit may be injured.

Table No. 3 will give results obtained, using 50 heaters to the acre.

TABLE III.
April 14, Fifty Heater per Acre.

Heater.	2.30	3.00	3.30	4.00	4.30	Increase.	
						Highest	Average
Ward	32.5	32.0	32.0	33.0	34.0		
	32.0	31.5	32.0	33.0	34.0		
Increase	1.25	0.7	0.25	1.0	1.0	1.25	0.25
Richardson	33.0	32.0	34.0	34.0	34.0		
	34.0	34.0	34.0	36.0	34.0		
Increase	2.5	2.0	2.5	3.0	1.0	3.0	2.20
Bolton	34.0	32.0	33.0	34.0	34.0		
	33.0	33.0	33.5	34.0	34.0		
Increase	2.5	1.5	1.5	2.0	1.0	2.5	1.70
Troutman	34.0	33.0	33.0	34.0	34.0		
	32.0	32.0	33.0	34.5	34.0		
Increase	2.0	1.5	1.25	1.75	1.0	2.0	1.30
National	33.0	33.0	33.0	34.0	34.0		
	33.0	32.0	34.0	34.0	34.0		
Increase	2.0	1.5	1.75	1.5	1.0	2.0	1.55
Hamilton Com		33.0	34.0	34.0	33.0		
		33.0	34.0	34.0	33.0		
Increase		2.0	2.25	1.75		2.25	1.50
Hamilton Reservoir		34.0	34.0	34.0	34.0		
		33.0	34.0	34.0	33.0		
Increase		2.5	2.25	1.75	0.5	2.5	1.50
Outside temperatures	31.0	31.5	32.0	32.0	33.0		
	31.0	30.5	31.5	32.5	33.0		

The outside temperature remained at 35 until 6:00 a. m.

The Richardson Heaters gave a slightly larger increase than was warranted because some were turned on too much and the oil ran out on the ground, causing them to burn very freely. This is a common fault with these heaters, as it is difficult with this grade of oil to regulate them so they will neither go out nor overflow.

The cost of this firing was slightly larger than the first, owing to the fact that three types of reservoir heaters were used, each consuming more than a gallon of oil; whereas, in the former test, only a gallon had been placed in each heater.

The refilling cost only 25 cents per acre this time, as only half the heaters needed refilling. The lighting cost 50 cents per acre, and the oil $3.37 per acre, making a total of $4.12 per acre for the second firing.

The Bolton Heaters gave the highest average increase of any of the gallon or five-quart heaters in this test. It was noticed, however, that the advantage was obtained because they made a rapid gain when first lighted and gave their maximum within a half hour after lighting. Thereafter the increase obtained dropped off quite rapidly to the end of the burning time. Since the maximum heat is desired late in the morning, usually near the end of the burning period, this is an objectionable feature with the lard pail type of heater.

The National Heaters were all burned without the storm hood, and from those on one-half the plot the perforated burner was removed. This was done to determine, if possible, whether any value could be attached to these burners. No difference was noticed in the amount of heat produced in the two sections, but the burning time varied a great deal. The heaters without the burner began going out at 4:30 and by 4:45 were all out, while those with the burners had not burned out until 6:30. This gave a difference of one hour and 35 minutes in favor of the burners, which furnished the same amount of heat, indicating that the percentage of combustion was higher with the burner than without.

This test was confirmed in the next burning, so that the difference is fairly constant, and shows that the perforated burners give a higher per cent of efficiency.

The Hamilton Lard Pail burned out very quickly and left a little residue.

A few of the Richardson Heaters caught fire inside the reservoir, causing one to boil over. This trouble was due to the fact that the wind blew the flame directly against the reservoir. They gave very little trouble, however, after 4 o'clock.

Table No. 4 gives (a) the time required to light and (b) the time at which the first and last heater went out and (c) the number of gallons of oil burned during that time per heater.

TABLE IV.
April 14, 1912.

Heater.	Time Lighted.	Time Out.	No. of Gallons.
National, with burner	1.45—1.50	6.00—6.30	1
National, without burner	1.45—1.50	4.30—4.45	1
Bolton	1.50—1.55	5.30—5.45	1
Troutman	1.45—1.55	5.45—6.00	1
Richardson	1.55—2.20	6.00 put out	2½
Ward	1.55—2.10	6.00 put out	2
Hamilton Com	2.10—2.20	5.00—5.15	1
Hamilton Reservoir	2.20—2.30	6.00 put out	1½

On the morning of April 15 a third frost was experienced. This was the most serious one of the entire season, as the two previous ones had been followed by a heavy fog after 5 o'clock, but on the morning of April 15, with the temperature ranging at about 30 degrees, the sun came out bright and clear in the orchard and the day was very warm.

The day previous the heaters had been filled to capacity so everything was ready for a test to determine the burning time of each of the heaters when filled to its working capacity.

It was not necessary to light the heaters until about 4:45, so that the two hours or two and a half hours which would have been required to protect the orchard was not enough to complete the test. Hence, the heaters were all allowed to burn until completely burned out.

Table No. 5 gives a tabulated report of the results.

The Ward Heaters were not very satisfactory when used with only one or two openings, as they had to be constantly relighted and during the last two or three hours of burning required constant care to keep them going.

TABLE V.

Burning Time of Heaters Filled to Capacity.

Heater.	Total Burning Time.	Burning Time per Gallon.	Per cent of Residue.	Remarks.
Richardson	14 hrs. 25 min.	2 hrs. 3.5 min.	....	Only light soot and scale.
Ward, 1st opening	43 hrs. 10 min.	6 hrs. 10 min.	40 per cent.	Heavy asphalt.
Ward, 2d opening	20 hrs. 35 min.	2 hrs. 57 min.	20 per cent.	Heavy asphalt, relit 4 times.
Ward, 3d opening	18 hrs. 35 min.	2 hrs. 39 min.	15 per cent.	Heavy asphalt, relit 3 times.
Ward, 4th opening	12 hrs. 15 min.	1 hr. 45 min.	10 per cent	Heavy asphalt, relit 3 times.
Ward, 5th opening	7 hrs. 15 min.	1 hr. 2 min.	....	Light scale with some asphalt.
Hamilton, open to 2d hole	10 hrs. 40 min.	3 hrs. 34 min.	5 per cent	Light scale and asphalt.
Hamilton, open to 3d hole	8 hrs. 30 min.	2 hrs. 50 min.	....	Light scale and asphalt.
Hamilton, open to 4th hole	5 hrs. 35 min.	1 hr. 52 min.	....	Light scale and asphalt.
Hamilton, open full capacity	2 hrs. 30 min.	50 min.	....	None.
Bolton	3 hrs. 32 min.	3 hrs. 32 min.	....	Only light scale.
Troutman	4 hrs. 10 min.	3 hrs. 42 min.	3 per cent	Heavy asphalt.
National, complete	5 hrs. 45 min.	4 hrs. 56 min.	....	Light scale.
National, without hood	5 hrs. 55 min.	5 hrs. 15 min.	....	Light scale.
National, without hood and burner	3 hrs. 33 min.	3 hrs. 9 min.	....	Light scale.
National, without burner	5 hrs. 40 min.	5 hrs. 1 min.	....	Light scale.
Hamilton Lard Pail	4 hrs. 34 min.	3 hrs. 36 min.	5 per cent	Asphalt.

Following this experiment some crude oil was obtained and a test was made with five heaters of each make, to determine, if possible, the difference in burning time with the Bolton, Hamilton Lard Pail and the National Heater, in several forms. None of the reservoir heaters were used with this oil, as they were not suited to its use.

Table No. VI shows the results.

TABLE VI.

Crude Oil.

Heater.	Total Time.	Time per Gallon.	Richmond Smudge Oil; Time per Gallon.
Bolton	4 hrs. 4 min.	4 hrs. 4 min.	3 hrs. 32 min.
Hamilton Lard Pail	7 hrs. 10 min.	4 hrs. 35 min.	3 hrs. 36 min.
National, without hood	7 hrs. 4 min.	6 hrs. 18 min.	5 hrs. 15 min.
National, complete	4 hrs. 35 min.	4 hrs. 4 min.	4 hrs. 56 min.
National, without hood and burner	3 hrs. 30 min.	3 hrs. 7 min.	3 hrs. 9 min.
National, without burner	4 hrs. 35 min.	4 hrs. 44 min.	5 hrs. 9 min.

The following table shows the composition of the different oils and reveals the fact that the number of B. T. units per pound is not a true indication of the value of an oil for orchard heating. It will be seen that the "flash point" and density will give a more accurate indication of the rate at which the oil will burn.

We are indebted to the department of experimental engineering for Table No. 7, the work being done by Mr. J. B. Yoder, under the direction of S. H. Graf, assistant professor of experimental engineering.

When gasoline was used in lighting; it was found that the heavier the oil the more readily it would light. The gasoline remained on the surface of the heavier oils but mixed very quickly with the lighter.

The oil used in the orchard work this year is a regular smudge oil put out by the Standard Oil Company and is known as the Richmond Smudge Oil, costing 75 cents per barrel at the factory. This is the same grade of oil which

TABLE VII.

Sample Number.	Density. Deg. Beaume.	Specific Gravity.	Flash Point. Open Cup. Deg. Fahr.	Heating Value. B. T. U. per lb.
1. Fuel oil	16.5	0.956	268	17,500
2. Crude oil	14.0	0.972	260	18,890
3. Richmond, Smudge oil	24.0	0.909	200	19,100
4. Slop distillate	18.0	0.946	140	18,620
6. Richmond, smudge oil burned 45 minutes	20.0	0.933	190	18,780
7. Richmond, smudge oil burned 75 minutes	17.5	0.949	250	18,710
8. Stove distillate	33.0	0.859	98	17,740
9. Richmond, smudge oil burned 30 minutes	22.0	0.921	212	18,880
10. Richmond, smudge oil burned 60 minutes	18.0	0.946	353	18,540

is being used largely in the Rogue River Valley this season. It has been found to be very satisfactory while giving slightly less burning time than crude oil. It is handled much easier and does not give the trouble with water that is experienced in using crude oil.

There has been one serious drawback, however, to the use of this oil, namely, the fact that the ordinary cement tank has failed to hold it. A few of the tanks which were used have been satisfactory, but a large share, even those which have been holding crude oil for several years, did not hold the lighter oil.

Fig. 10. Pumping oil from a car into the storage tank.

Under existing conditions it is probably best to use some form of a steel tank, although such tanks are more expensive.

A preparation of soap, tallow and resin could be used quite successfully with cement tanks if the leak is only small. This should be applied hot on the inside of the tank. The proportions of the mixture are: Soap, seven parts; tallow, two parts; resin, four parts, by weight.

Considerable work was done during this season with ordinary commercial thermometers (which can be purchased in the store), and with some of the especially designed orchard thermometers, but from a standpoint of the orchardist, they are all very unsatisfactory. Some of the better grades that are

accurate, are not sensitive enough and do not respond quickly enough to changes in temperature. This was found particularly true of the large round bulb type. It was also true with the cheaper thermometers which were purchased in the local market.

The especially designed orchard thermometers which were tested, were those put out by the Cederborg Engineering Company and the Taylor Instrument Company. The former were very sensitive and accurate, but the graduations are too small and the thermometer itself is too small for practical orchard use.*

The instruments purchased of the Taylor Instrument Company are not sensitive enough; several minutes were required at times to record a change of one or two degrees in temperature.

A great many cheap thermometers were tested, but in no case were they found reliable, varying all the way from one to four degrees in error.

The question of thermometers for orchard use is one which has not been given enough attention. Too often the orchardist will rely upon only one or two thermometers for eight or 10 acres of orchard, thinking that the entire area which he is heating is under the same influence.

As the orchardist becomes more experienced in the use of heaters, he will begin to realize that the saving of a few minutes burning time will mean just that much less cost, and he will find that it will pay to supply his orchard with thermometers so that he may use only what oil is absolutely necessary.

Two types of frost alarms were tried out during the season; one a spring type, the other a battery type. The one having a dial and spring thermometer was not found satisfactory, the spring thermometer not being sensitive or accurate enough and being subject to a good many troubles. The battery type is probably the best type of frost alarm on the market today. It is one using a set of batteries connected with a mercury themometer and depending on the rise and fall of the mercury for sounding the alarm.

Fig. 11. Filling orchard heaters from a tank wagon.

The one which was tried out of that type this season gave excellent results, never failing to ring at the time at which it was set. The function of the orchard frost alarm, however, is only that of warning against an unexpected frost, or of rousing the men in case they are sleeping in the orchard and can be gotten out in a very few minutes.

*Mr. F. R. Brown, after carefully considering the needs of an orchard thermometer, designed one which should meet all requirements and yet not be too expensive. This thermometer may be obtained from the "Central Scientific Co.," 345 West Michigan Street, Chicago, Ill.

The frost alarm should be set to ring not lower than 33 degrees and not higher than 35 degrees, for if it is set higher than 35, it would often ring unnecessarily, but on the other hand, if set below 33 there would not be time enough to get into the orchard and get the heaters lighted.

The frost alarm should only be used in conjunction with the weather bureau service, which adds a great deal cf comfort to the man in charge, as he can feel sure that no frosts will take him unawares.

Capacity of Heaters.

The different types of heaters were measured to obtain their full capacity and also their working capacity.

In Table No. 8 will be found a list of heaters with their capacities, cost per hundred and the address of the agent.

TABLE VIII.

Heaters.	Capacity.	Working Capacity.	Cost per hundred.	Agent.	Address.
Ward	8 gal.	7 gal. 7 pts.	$85.00	Common Sense Orchard Heater Co.	Clifton, Colo.
Richardson	7 gal. 1 pt.	7 gal.	55.00	Richardson Frost Prevention Co.	Kansas City, Mo.
Hamilton Reservoir	3 gal. 4 pts.	3 gal. 1 pt.	45.00	Hamilton Orchard Heater Co.	Grand Jct., Colo.
National	1 gal. 4 pts.	1 gal. 1 pt.	20.00	National Orchard Heater Co.	Grand Jct., Colo.
Bolton	1 gal. 1 pt.	1 gal.	20.00 delivered	Geo. H. Parker	403 West D, Grants Pass, Ore.
Troutman	1 gal. 1 pt.	1 gal. 1 pt.	20.00	Round Crest Orchard Heater Co.	Canon City, Colo.
Hamilton Lard Pail	1 gal. 2 pts.	1 gal. 1 pt.	12.00	Hamilton Orchard Heater Co.	Grand Jct., Colo.

Summary.

Twenty-six acres of prunes were used in the work this season. Of this area 12 acres were equipped with Bolton and Hamilton Lard Pail Heaters, placed 100 to the acre. Four acres were supplied with Hamilton Lard Pail and Reservoir Heaters, placed 50 to the acre. Three and one-half acres were

Fig. 12. National Orchard Heater. Showing reservoir and burner, cover and storm hood.

used as the seven different plots for testing the types of heaters and the other six and a half acres were left as a check.

The Richardson reservoir heater was the only one which would burn the Richmond smudge oil mixed with water. The National Heater gave one hour and twenty-four minutes longer burning time than the Troutman, and one hour and 48 minutes longer than the Bolton heater with the measured gallon of oil. It also gave 55 minutes longer burning time than the Hamilton reservoir with a smaller opening. None of the other reservoir heaters burned as long as the Hamilton with the measured gallon. The Bolton heater gave a little higher increase in temperature but did not keep it up as long as did the National, which was second highest. The Richardson reservoir, burning 100 to the acre, did not equal either the Bolton or National.

The total cost of the first firing averaged $3.67 per acre. In the test plot the cost per acre reached $4.12 for the second firing, as the reservoir heaters used more oil. The average for the rest of the orchard for the second firing was $3.38 per acre. The cost of the third firing was only $2.72 per acre, as only three quarts of oil were burned in each heater. The average cost per acre for the season for each firing was $3.47. The total cost was $9.77 per acre for the season.

The frosts occurring this season were not severe enough to make the test of a great deal of value except to determine the value of the different types of heaters. The whole orchard produced a good crop, the yield on one part being as high as four and one-half tons per acre.

The fact that the drop was as heavy as usual and that the temperature did not fall below 32 degrees in the orchard, would indicate that the dropping of those immature prunes was not due to frosts after the blooming period.

SEEDLESS AND MALFORMED FRUITS.

By F. R. BROWN.

There has appeared each year, sometimes in all parts of the state, and again only in one or more districts, an injury to fruits making them more or less unsalable. This has been attributed to various causes by the growers, some calling it spray injury because of its resemblance to the well known Bordeaux injury, others giving the cause as apple scab because the tissues affected act in much the same manner as when attacked by the scab. But those who have studied the matter agree that it is the effect of a frost occurring after the fruit has set.

Bailey, in his Principles of Fruit Growing, mentions a certain russeting of pears and apples caused by frost, and notes that the tissues so injured sometimes cease development and the fruit grows one sided. Smith, in his California Plant Diseases, reports that mature pears are sometimes found with a scabby or russet band around them and that the fruit is nearly always constricted in the region of this band. M. Chevallier reports that in some parts of France a large number of pears are found with this band extending entirely around the fruit just above the calyx. This russeting he attributes to frost, and states that the varieties Doyenne Boussoch, Doyenne D'hiver, Doyenne D'Alencon and Louise Bonne are especially subject to it.

During the last two years we have had occasion to study the action of frosts on apples, pears and prunes, and find that a light frost occurring after the fruit has set will sometimes cause a russeting on the surface of the fruit. On the pear this usually appears as a band extending entirely around the fruit, at or near the calyx end. In mature fruit it may be as much as half an inch from the calyx, extending from half an inch to an inch in width and usually causing a constriction at that place. During the season of 1911 this injury appeared in one orchard on d'Anjou pears, while Bartletts on one side and Winter Nelis on the other did not show any effect of frost. The injury could be detected by the time the fruit had become an inch in length.

The frost injury on apples and prunes is different, as it appears usually on one side of the fruit, sometimes constricting the growth of the tissues on that side and sometimes stimulating them to abnormal growth. Apples are less often russeted by frost. They bloom so late that the frost season is over by the time the fruit has attained such a size that a frost sufficient to cause a russeting would not kill the fruit itself.

The injury on prunes sometimes covers one side of the fruit, but more often only a spot about the size of a dime. The spot is a rough, grey russet, and sometimes causes an abnormal growth. A number of prune growers mistaking this frost injury, have reported apple scab on prunes, and some few have sprayed (without results) as a remedy for the evil. During the season of 1911 this injury appeared in every prune section in the state; it was most damaging in orchards where the young fruit had largely been killed by frost.

Fig. 13. Bartlett pears injured by frost.

Though it seldom retards the growth of the prune, it shows very plainly after drying.

Malformation may appear in different forms, and while in some instances it is accompanied by a russeting of the epidermis, there are numerous cases in which the tissues are not injured. Little seems to be known of this, although in this state it is quite common in pears.

It is a well recognized fact that there are two effects of pollination: First, the fertilization of the ovules which develop into seeds; and second, a secondary stimulation through the seeds themselves, which may or may not become fully developed, resulting in the growth of the fleshy part of the fruit. Cases of parthenocarpie, or the development of a fruit without pollination, are, of course, known. Fruits which do not normally develop without pollination, however, are more or less deformed when they do develop without pollen.

After fertilization a more or less severe frost may bring about a greater or less injury to the very young seeds. This may result in the death of the young seeds, in the death of the embryo only, in which case the endosperm continues to develop, or merely in a decided weakening of their growing powers. The degree of such injury is clearly reflected in the subsequent growth of the young fruit. If the seeds are killed outright, growth in the region of the ovary is almost completely stopped, though it continues in the torus, or what is commonly spoken of as the neck, of a pear. Fig. 14 will show such a pear with the ovary only partly developed. If the seeds are but slightly injured, however, the fruit will attain nearly full size.

Fig. 14. Bartlett pear injured by frost. The stem end normally developed, the calyx end showing little growth.

A large number of these frosted pears remain on the tree until picking time, but most of them drop a little in advance of the normal season. This early dropping has been generally attributed to a lack of moisture in the soil, excessive heat, etc. Close examination will show, however, that most of these pears are seedless, or have seeds only partly developed.

Among a large number of Bartletts examined in 1911 cases were found showing different stages between the two extremes, as is shown by Fig. 13. In such pears it was found from the weight of both seeds and fruit that the development of the fruit was very closely related to that of the seed. In all cases larger and heavier fruits resulted when fully developed seeds were present.

In some instances pears were found that closely resembled fruit that had received no foreign pollen. Fruits of the Bartlett pear which result from

self-pollination resemble to a remarkable degree those specimens of frosted fruit which show the greatest development.

It is found, also, that these selfed fruits usually contain seeds which are abortive, resembling very closely the larger seeds from frosted fruits. This striking similarity in the relative flesh and seed development resulting from two distinct causes, only emphasizes further the dependence of the flesh development as a secondary result of seed formation.

One other effect of spring frosts was noted this year. It appeared on the young leaves of pears and cherries. The injured leaves were about one-fourth full size and became much thickened and wrinkled, with the edges curled up much the same as leaves affected by peach leaf curl. After they had attained full size, these leaves dropped off and the injury disappeared. The injury was first observed on pears and cherries in a nursery, and later on the leaves of mature pear trees in different orchards.

From our observations we must conclude that buds injured before pollination may be either entirely killed or so devitalized that they will be unable to set fruit. Blossoms or fruits frosted after fertilization has occurred, may become russeted, malformed or seedless. The malformation on Bartlett pears is due either to a partly or entirely seedless condition.

GREENHOUSE TOMATO INVESTIGATIONS.

By A. G. BOUQUET.

The business of growing vegetables under glass is undergoing a steady increase all over the state. Tomatoes, lettuce and cucumbers are being grown much more extensively than formerly. These crops in order to be most profitable must be produced so as to get a good market price and at the same time satisfy the popular demand. Of the three crops named, the forced tomato is probably the one which will bring the grower the most money under ordinary conditions.

At the present time the majority of the growers of tomatoes under glass are divided in their opinions regarding the most suitable variety or varieties to be forced. While there are a number of growers who seem united in their opinion, there are a good many others who at the present time are growing a number of varieties, without, however, keeping any definite records as to the behavior of these varieties under glass and their marketable characteristics.

The greenhouse tomato, as it is demanded by the open markets at the present time, should have certain definite characteristics which include earliness of maturity, fine quality, productivity, uniformity in size, color and shape, all of which have their definite bearing on the financial outcome of the crop. If the general public is to pay a price of from 15 to 30 cents per pound for greenhouse tomatoes, they must be fine in quality, smooth and of good color. At the present time the market demands a tomato weighing from four to eight ounces and packing from 18 to 24 into a four-quart basket, four of these baskets comprising a crate. Packed in this manner as a fancy article and put on the market as such, early prices, varying of course through different years, will net the grower 10 to 20 cents per pound, or from 15 to 30 cents per pound wholesale.

There are probably about six varieties of greenhouse tomatoes that are grown very largely by commercial greenhouse men. Accordingly, in this investigation work, it was planned to select these half dozen varieties and submit them to a test which would show their behavior under similar conditions and demonstrate their commercial value.

One of the most important factors influencing early production of fruit and productivity throughout the entire season, is the satisfactory fertilization of the blossom clusters. In order to get the best prices prevailing on the market during the early season, it is necessary that these first blossom clusters set their full percentage of fruit, while for plants to bear heavily it is necessary that but few blossoms be lost through dropping during the entire season. With some varieties it would be impracticable and undesirable for all their blossoms to set fruit owing to the large number of blossoms produced, yet under most circumstances many varieties setting all their blossoms can be made to produce that number of fruits of marketable size.

Considerable progress has been made in the problem of tomato pollination. Much helpful work has been done by the Michigan Agricultural College, principally by O. I. Gregg. Little is known at the present time, however, regarding the individual peculiarities of various varieties in regard to their comparative sterility. This phase of tomato pollination will be brought out a little later in a discussion regarding the various flowers and blossom clusters of individual varieties.

The following outlines are phases of investigation work undertaken during the past year.

1. Test of six varieties to contrast qualities of marketable value, such as earliness of maturity, uniformity in size, color and shape, productivity, etc.
2. Comparative efficiency and economic value of different means of artificial pollination.
3. A study of individual variety blossom and blossom clusters, determining, if possible, variation of varieties in regard to these characters and its economic value in producing fruit of marketable characteristics.
4. Comparative test of rows and plants fertilized and unfertilized.

Varieties.

The following varieties were included in the above tests: Earliana, Jewel, Bonny Best, Lorillard, Comet, Stirling Castle. In all, 12 rows of tomatoes were planted in each greenhouse bed, two rows of each variety on the west bed and two of each on the east bed. The seed of all varieties was sown January 1 and the plants bedded from March 7 to March 9. The first ripe tomatoes were borne May 25. From that time on, individual records were kept of the weight of each fruit, of every plant and row, until the time at which the outdoor crop was generally on the market and prices decreasing rapidly. From May 25 to June 13, inclusive, a separate record was kept of the production of each variety in the east and west beds, summarizing the amount of fruit which was produced between those two dates.

Training and Pruning.

The plants were set in the beds two feet apart each way. The method of handling the plants in the bed was according to the single stem system, the pruning of laterals being done when necessary.

Fig. 15. Earliana blossom cluster showing various stages of development and prolific character of variety.

Pollination.

The pollination of the blossoms was carried out by two methods: First, by jarring the vines during bright days; and second, by transferring the pollen under similar conditions. Check rows were kept on each of these two methods. The work of pollination was regularly and consistently carried out by two student assistants, J. M. Franklin and George McFarland, under the supervision of the writer. In regard to the first method of pollination, the blossoms were tapped during the warm bright part of the day and as nearly as possible the artificial method of transferring pollen was carried on about the same time. Method No. 2 in pollinating by hand was carried on in the following way: No spoon or camel's hair brush was used but the pollen was shaken from those blossoms nearly open to the first finger of the right hand, from which it was quickly applied to the pistils of the cluster. This seemed to be as rapid a manner of conveying the pollen from one blossom to another as has yet been tried in this comparative test.

In the work of pollination a record was kept not only of each individual plant, but also of each individual blossom cluster, in order to determine the number of fruits lost by the lack of fertilization of those particular blossoms. In this way a record would show a definite comparative statement regarding the efficiency of hand pollination over other methods.

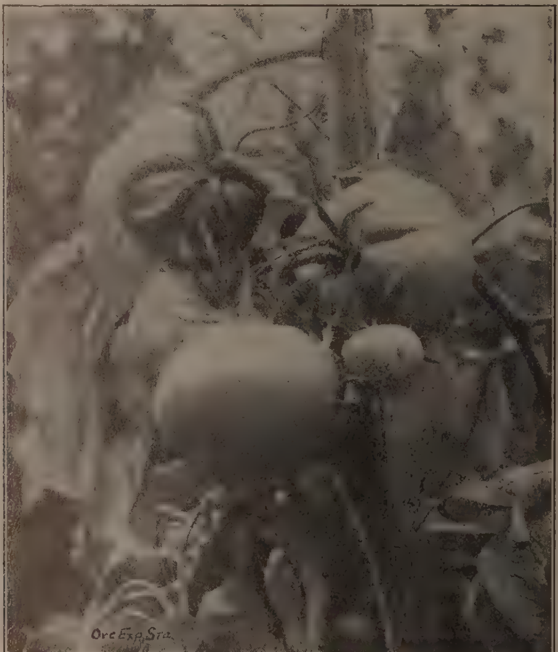

Fig. 16. Fruit cluster of Bonny Best.

Tabulated Records.

Two general tabulated records of the behavior of individual varieties have been kept, summaries of which will be stated later. First, records of production in ounces of each individual plant of all varieties were kept from

May 25 to June 13, inclusive, demonstrating the amount of fruit produced by each variety in three weeks after the first variety began to bear ripe fruit.

Tabulated records No. 2 shows the total productivity of each plant of individual varieties with the number of fruits of a certain number of ounces. Samples of these tabulations are listed below.

Contrasting tables are also included to show the behavior of the varieties of fruit in regard to the following: First, varieties bearing the largest number of ripe fruits of marketable size between the dates of May 25 and June 13, averaging between four and eight ounces inclusive; second, the varieties producing the largest total of marketable fruits averaging between four and eight ounces for the whole season; third, the comparative productivity of plants and rows first by tapping, second by hand pollination, and third by no artificial aid.

In order to illustrate the value of the above, sample tables are included herewith giving the figures for the comparative tests.

TABLE I.

Total number of ounces of fruit produced between May 25 and June 13, inclusive. One row each of four plants.

Variety.	Pollinated by jarring.	Not pollinated.	Total increase in oz. in favor of jarring.
Earliana	215½	59	156½
Bonny Best	202	96½	105½
Jewel	167	52	115
Comet	95½	53½	42

TABLE II

Varieties producing largest number of marketable size fruit from 4 to 8 ounces, (inclusive) for period from May 25 to August 30.

Variety.	Total for 4 rows of each variety (4 plants in each row).
Jewel	248
Bonny Best	367
Earliana	390
Lorillard	234
Comet	281

TABLE III.

Total number of ounces of fruit produced (one row each) between May 25 and June 13, inclusive.

Variety.	Pollinated by jarring.	Pollinated by hand.	Total increase in ounces in favor of hand pollination.
Jewel	113	253½	140½
Earliana	215½	338½	123
Bonny Best	202	270	68
Comet	95½	103	7½

TABLE IV.

Total number of ounces of fruit produced (one row each) between May 25 and June 13, inclusive.

Variety.	Pollinated by hand.	No artificial aid.	Increase in ounces.
Jewel	253½	52	201½
Earliana	338½	59	279½
Bonny Best	270	96½	173½
Comet	103	53½	49½

TABLE V

Total number of ounces of fruit produced through season, May 25 to August 30 (One row each of four plants).

Variety.	Hand pollinated.	Jarred.	No aid.
Jewel	749	589	506
Earliana	980	812	689
Bonny Best	835	707	651
Lorillard	683	619	463
Comet	719	648	469
Stirling Castle	discarded.	....	....

Summary.

1. On ground bed in which hand pollination was carried on the plant producing largest amount of fruit between May 25 and June 13 was of the variety Earliana, total 107 ounces, or 6 pounds 11 ounces.

2. On same bed as above eight plants produced from 60 to 100 ounces between the limiting dates, while on bed in which jarring was practiced but three plants produced that amount in the same time.

3. Contrasting average amount produced per plant in ounces between the two above pollination methods shows, for hand pollination 61½, for jarring 37½.

4. As regards the behavior of varieties, plants fertilized and unfertilized showed no results definite enough at this time for publication.

5. The above tables show a sign of superiority in the earliness and productivity of the variety Earliana. This variety is notably characteristic on account of its remarkable blossom clusters, in which respect it is very prolific. The variety, however, offsets its important characteristics of earliness and productivity by its irregularity of shape, roughness and poor quality. In this

Fig. 17. Bonny Best tomato, a variety having many desirable characteristics and worthy of further trial.

respect the Bonny Best is decidedly superior, making it a much more desirable variety for those reasons. These varieties showed superiority and prominence over the rest, making them especially important for later investigations.

The variety Jewel resembles the Bonny Best in many characteristics, especially in foliage, blossom clusters and general shape, size, color and quality of fruit. According to the above tests, however, it is inferior to the rest named in earliness and productiveness, also running slightly under size.

The Comet, while producing clusters of fruit of excellent shape and smoothness, tends towards somewhat inferior size and does not prove to be as prolific or as early as some of the other kinds.

The Lorillard, according to the present tests, does not seem to have proved sufficiently valuable for tests the coming year, and Stirling Castle was later disqualified, after proving to be of little commercial value.

In addition to the above, regular observations have been made the past year on the comparative number of fruits lost through failure of blossoms to set, by each method of pollination. Thus a complete record of each individual blossom cluster and individual blossoms have been accounted for, as follows:

Variety.	Date.	Cluster.	Blossoms pollinated.	Blossoms not yet out.	Blossoms set fruit formed.
Jewel	June 1	1	1	3	3

Fig. 18. The 3 x 3 pack of tomato in the veneer 4 quart basket.

Future Investigations.

1. Owing to the above statements being the result of but one year's investigation work, these cannot be considered at all final. Many of the above tests, together with others of importance, will be pushed the coming year. Those varieties which have proved of value over others will again be included with an increase of space.

2. The efficiency of each method of pollination will also be thoroughly tested in its relation to each variety.

3. Seed from this year's crop has been saved for future planting, in order to begin the breeding of a strain satisfactory to our greenhouse conditions.

4. With the planting of old varieties and additional new ones, blossoms and blossom clusters will be made the subject of special investigation in order to overcome the problems connected with artificial pollination.

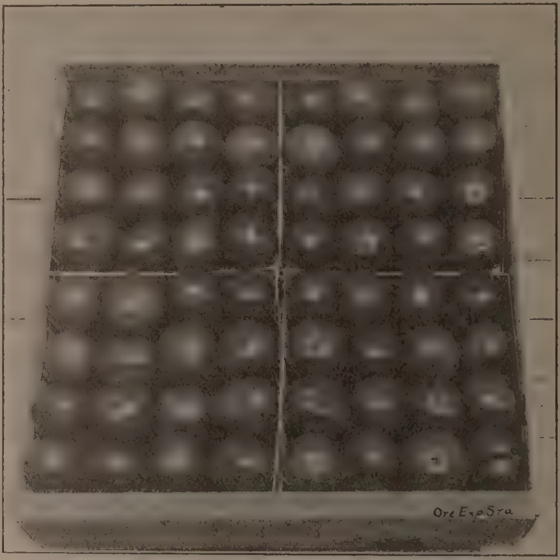

Fig. 19. The 4 x 4 pack for tomatoes inferior in size to those in Fig. 18.

THE DRYING OF PRUNES.

By F. R. BROWN and F. C. BRADFORD.

Prune drying as it exists in the northwest is of local origin. Conditions, either local or climatic, are different here from those obtaining in the other prune producing regions of the world. The earlier attempts at adjustment to these conditions were made, therefore, of necessity, without precedent and at considerable cost. Numerous types of dryers have been tried, with varying success, until the gradual process of elimination of unsatisfactory types and the evolution of better, has resulted in an approach to uniformity of types and to some extent of the product.

Nearly all the dryers used in the state at present may be classed under two main types—the tunnel and the stack. The fundamental principle of these types is to subject the fruit to a gradually increasing heat so that the maximum temperature is reached shortly before or at the time when the drying is finished.

The tunnel dryers in turn present several models; these models are again frequently varied to conform with the ideas of the man constructing the dryer. As a type, however, the tunnel dryer may be described as a group of long, nearly horizontal wooden tunnels, arranged side by side over a fire-pit. The tunnels vary in length from 25 to 40 feet, in height from four to six feet; the slope from end to end is between two to three feet. Each tunnel may be complete in itself or the walls between tunnels may be partly open. Along the walls are nailed cleats or rollers which both support the trays of fruit and serve as a track along which they are pushed. The fruit is introduced fresh at the upper end and taken out dried at the lower end. As a tray is removed at the lower end, a fresh tray is placed in at the upper and the whole row pushed down one "notch."

In some of the older tunnel dryers light frames on wheels, commonly known as cars, are used for carrying the trays of fruit from one end of the tunnel to the other, but the present tendency is to discard the cars and push the trays along the cleats. In either case the trays are arranged one above another in tiers, with a three or four-inch space between. At the lower end the trays are arranged so that each has an overhang of about two inches beyond the one below it, thus intercepting part of the ascending heat and deflecting it to the space between the tiers.

The length of the tunnel, as already stated, varies between 25 and 40 feet. In some cases where forced draft is used, the tunnels are 50 feet long. For the ordinary dryer, however, 35 feet is the maximum length advisable; longer tunnels are likely to impede air circulation. A dryer's capacity can be enlarged to better advantage by increasing the number of tunnels rather than by increasing the length of the tunnels already in operation. The slope of the tunnels has been mentioned already as varying between two and three feet, depending on the length of the tunnels. The older type which used cars was built with a "dip," the tunnel sloping till it reached its lowest point a few feet from the lower end; beyond this it rose.

The heating pit is directly below the tunnels; sometimes it extends their full length, but more often only the lower part of the tunnel is above the pit. The heating is done by brick arch furnaces or by stoves of iron or steel. The "hop stove," 2x2x5 feet, is the most common device used in the newer dryers; one of these stoves is generally considered sufficient to heat three tunnels. In very large dryers the pits are subdivided; this permits of shutting down part of the dryer without interfering with the part in use. To secure a more complete utilization of the heat, long pipes leading from the stove to the chimney are used. These pipes vary between nine and 15 inches in diameter, the size decreasing somewhat with the increasing distance from the stove. The pipe is conducted back and forth inside the pit until the length used per stove frequently exceeds 75 feet. By the time the gases of combustion reach the chimney after traversing all this length of pipe, they have usually given up most of their heat.

These pipes are often a cause of fire, especially when they are placed too close to the wood work above or when the accumulation of charcoal from the "drip" ignites and communicates the fire to the woodwork.

The distance from the topmost pipes to the floor of the tunnel generally ranges from six to 11 feet; in general, it may be stated that the greater this distance the more even is the distribution of the heat and the less the danger from scorching of fruit on the lower trays. Generally the greater the distance the larger the opening into the tunnel. Sometimes a sheet of corrugated iron is placed above the stove to deflect part of the heat and prevent an excessive upward rush of hot air. In other dryers a similar sheet is pulled over the opening to the tunnel, thus obviating the necessity of working in a strong current while taking out the dried fruit.

The time required to dry a tray of prunes varies widely, more so than it should. Eleven to 40 hours are the extreme periods reported. In the same dryer, with the same crew, there is often a considerable difference in the amount dried from day to day; the total depends upon the way in which the weather affects air circulation and humidity, upon the size and ripeness of the fruit and upon the quality of fruit that is being turned out.

The stack dryer is arranged to contain trays placed one over another. The bottom of the stack is open. The hot air enters from below, passes up through the trays and out through a ventilator at the top. These dryers are much alike in essentials, differing principally in the way in which the trays are put in or removed. A single stack of the older type consists of a vertical series of three or four small compartments open to each other and each holding three trays spaced three inches apart. The fruit is first placed in the top compartment, and after a slight drying must be taken out and placed in a lower compartment, thus requiring much extra handling. In these dryers the number of stacks for each furnace varies from eight to twelve.

In the newer types all the compartments are merged and the trays, numbering usually from 12 to 17 per stack, rest directly upon one another. Each stack is fitted with a lever and catches (called "dogs") which raise all the trays slightly and hold them suspended while the bottom tray is removed, then when the lever is released they are lowered one "notch" and a place vacated at the top ready for another tray. Fresh fruit is introduced at the top and the dried fruit taken out at the bottom. Some of the "lifts" will work either way so that the trays may be started at the bottom and finished at the top; this is an advantage when other fruits are being dried. The trays between the bottom and the top cannot be inspected during the drying.

Twelve stacks is the usual number heated by one furnace; these rest directly on a pit similar to that used with the tunnel dryer. Too little distance between the hot air pipes and the bottom of the sacks is even more likely to cause scorching of the fruit here than in the tunnel dryers.

Stack dryers probably turn out a little the more fruit in a given time than those of the tunnel type, because of the fact that the air currents always move upward and the heat is not diffused over so great an area. The range of extremes is about the same as with the tunnel dryers.

Though in most cases the greater proportion of scorched and over-dried fruit comes from dryers of the stack type, it must be understood that they are capable of turning out as good a product as the tunnel dryers. Often the quality depends largely on the man in charge, for though some men are producing better dried prunes from stack dryers than other men are from the tunnel type, the converse is equally true.

The Oregon Kiln or Jory dryer is entirely different from the types already described. The essential part of this dryer is a brick kiln, somewhat conical in shape. At the bottom of this is the furnace, commonly a hop stove; the smoke pipe ascends as a vertical axis and passes through the roof at the apex. Concentric with this is the ventilator flue. Above the stove and around the pipe is hung a skeleton revolving rack, on which are placed the trays. These trays are peculiarly shaped, reminding one, to use a homely illustration, of a wedge of pie with a generous bite removed from the apex.

There is a general upward current of air in this dryer, it is true, but it is uneven on account of the many open spaces through which the air rushes, tending to avoid the center of the trays. This tendency, noticeable in all types, is more marked here. Furthermore, the smoke pipe itself frequently becomes over-heated. These two conditions make the fruit at the edges of the trays subject to scorching before the fruit at the center is dried. In addition it should be remembered that the contents of the kiln must be handled as a whole. To illustrate: When the temperature of the kiln is at the proper point for finishing the drying, if a few trays are finished before the others, as often happens, they must be taken out, but no fresh fruit can be put in the vacated places till the temperature of the whole kiln is reduced to a point suitable for beginning drying. This means a considerable loss in efficiency. With all these faults, however, it must be conceded that this dryer sometimes turns out very fine fruit; when it does, it is a tribute to the man in charge.

Steam is used in two very different ways in drying prunes. One of the older dryers has numerous shelves formed of steam pipes on which the trays are laid. This type is not being constructed now. Another steam dryer is essentially a tunnel dryer, except that the air is warmed by passing over a large coil of steam pipes and is forced through the tunnel by a big blower. This type is to be commended in many ways, but its large initial cost makes it unavailable for the average grower.

Several other types of dryers have been developed recently, but the prune grower should consider very carefully before abandoning the relatively inexpensive tunnel or stack dryer.

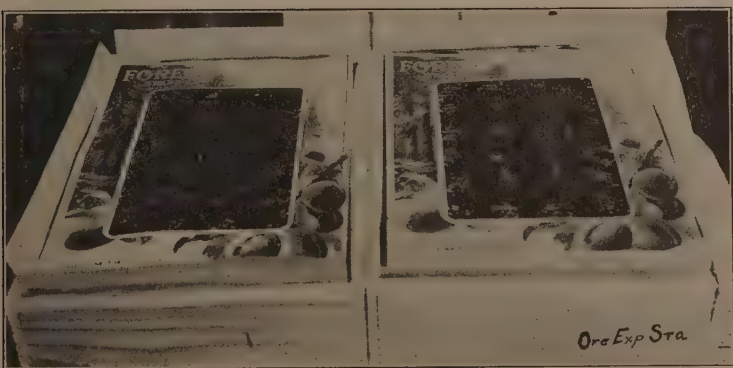

Fig. 20. Italian prunes after evaporation and processing.

The manufacture of good dried prunes begins before they reach the dryer. The necessity of securing properly ripened fruit has been touched upon elsewhere, but a word or two should be added here. Not only does properly ripened fruit make a better dried product but uniformity in this respect is direct economy. Some facts noted by one of the writers in a dryer where unevenly ripened fruit was being handled, are instructive enough to be added. Two women were employed in picking "pogies" or "bloaters," or in other words, unripe prunes, from the trays of finished fruit. The pogies were not yet dried, even though some of the ripe fruit had been slightly scorched; they were placed upon trays again and sent back for further drying. One man spent most of his time in handling this unripe fruit. Careful count showed that 25 per cent of the fruit taken out had to be sent back. Thus the wages of two women and one man, in addition to the cost of the extra drying, were added to the normal cost of the work. The quality of the product, moreover,

was materially lowered. The ground in the orchard was heavily sprinkled with broken spurs and twigs, where the fruit had been clubbed from the trees.

It is possible to err almost as badly in the other direction, permitting the fruit to become overripe before drying, but this mistake is less common. In seasons when brown rot is abundant such a practice is especially disastrous. Even without the brown rot, a fermentation sometimes starts which is likely to cause "drip." Furthermore, overripe fruit is likely to be crushed severely in handling before it reaches the trays and the broken skin permits the juice to run out, making another cause of "drip."

The prunes in orchard boxes should be unloaded on a covered platform large enough to hold at least half the amount required for 24 hours and located so that it is close to the dipping vat. The dipping and spreading must be so arranged as to avoid any unnecessary movements.

Dipping.

The object of dipping prunes is to crack or "check" the skin so that subsequent drying is hastened. "Dipping" is a very brief immersion of the prunes in water, either hot or cold, and with or without lye. Hot water, usually supplied by a coil connecting with the furnace, is used in most cases and is undoubtedly to be preferred to cold water. Lye is commonly used, at the average strength of one pound to from 30 to 50 gallons of water; less is necessary when hot water instead of cold is used. Here again is shown the desirability of having the fruit evenly graded according to ripeness, for an immersion barely sufficient to check the green prunes will take the skin completely off the ripe fruit.

The dipping in lye has been condemned severely at times as deleterious to the health of the consumer. It is safe to assert, however, that when proper rinsing is given, there can be no valid objection to its use arising from the presence of lye itself in the fruit. The objection to the use of lye comes from the fact that it permits other practices that are not only questionable but objectionable. Too often the lye is used to remove traces of "mold" from half-rotted fruit that should never be marketed.

That it is possible at times to dry prunes well without dipping in lye or even without dipping at all is proved by the experience of some who have turned out good fruit with this process omitted. For average conditions, however, dipping at least in hot water is recommended, and a moderate use of lye should not be discouraged. Hot water alone has been found a very good agent for checking prunes, especially when the fruit is plunged into cold water immediately upon coming from the hot. The contrast in temperature seems peculiarly favorable to the checking.

Attention to proper rinsing is to be urged strongly upon those operating dryers. Conditions could be improved vastly in many dryers with little trouble or expense. Frequent changes of rinse water are essential and often rinsing in two waters is desirable. Whenever running water is available the supply in the rinse tanks should be constantly renewed. Unless this rinse water is frequently changed so much lye will come over with the prunes that the rinse water will be nearly as strong in lye content as that used in dipping. This statement may seem an exaggeration but it has been proved in some cases by chemical examination of samples collected by the writers.

In moist, rainy weather, washing the fruit with fresh cold water before dipping will be profitable. Without this preliminary cleaning the fruit will be muddy when immersed in the lye water; the part of the prune that is covered with mud is not acted upon by the dipping solution and the purpose of the dipping is partly defeated.

Various kinds of apparatus are used for dipping, rinsing, and traying. Most of them appear to work well, though there is some difference in the efficiency of the various types. The power driven machines are undoubtedly the most economical and efficient but their use is hardly warranted in a small dryer. When a rough grading for size can be combined with the dipping, a considerable advantage is gained, because the fruit will dry more evenly.

TABLE I.
Dipping and Traying.

Type of Dipper.	Cost of dipping and traying per ton.		
	Labor.	Interest on Investment.	Total.
Home made	$1.24	.04	$1.28
San Jose	.24	.62	.86
Kurtz	.28	1.15	1.43
Payne	.22	.50	.72

This table is designed to show what part labor-saving machines play in reducing the cost of drying. It is not exhaustive, for not all the patent types are listed, nor are the figures given unvarying; much depends upon the men working, upon the convenient location of the machine and on the power used in operating it. The calculations are made from observations on the performances of the machine and upon an arbitrary assumption of a total output of 20 tons per season. The total interest at 8% on the output is divided by 20 to determine the interest per ton. It is obvious that the interest charge per ton, which is the larger item with the patent dippers, will decrease when the output is over 20 tons. The labor cost will not increase pro rata with the output. With the home-made outfits the interest charge is a negligible factor in any case and the labor charge will increase very nearly pro rata with the output. It is evident, therefore, that the power outfits become increasingly desirable when larger quantities of fruit are to be handled.

Even when the seasonal output is somewhat smaller than 20 tons the power outfits will often be found economical. To illustrate this point the practice in one dryer is cited. In this dryer the night and the day men, working together for an hour each in the morning and in the evening, dip and tray enough prunes with a power outfit to last through the 24 hours, thus saving the cost of a dipping crew.

Bleaching.

Bleaching is not practiced to any extent, in fact, it is rather in disfavor at present. What few prunes are bleached are principally Silvers. The process is simple but requires some little experience and judgment. Before the drying is begun the trays of fruit are placed in a closed compartment at the bottom of which a small amount of sulphur is burning. The exposure is for only a few minutes, the exact time depending on the amount of sulphur burned. Trays made from galvanized wire screening are injured by the sulphur fumes.

Drying.

There appears to be substantial agreement among those who dry prunes as to the general principles of the work. The differences of opinion are minor and are often attributable to individual experiences in different dryers. All are agreed, for instance, that to increase the heat gradually is the best way to dry prunes, nearly all agree that the longer the fruit is in drying the better the product, and most are agreed that the best temperature for finishing drying lies between 160° F. and 185°.

There are some principles that, though they are rather generally understood, should receive emphasis here. One of them is this: drying is not curing. With our looseness of terms we speak of drying when we mean curing; drying is the mere drying off of moisture while curing implies, besides the loss of moisture, certain chemical changes in the fruit. Sudden exposure to extreme heat, if it does nothing worse, will prevent a prune from curing properly. The fancy prunes which our market imports from Europe are dried for a long time at a temperature that to people in this country would seem extremely low. For this reason, other things being equal, better prunes will come from a dryer that holds a large amount of fruit and dries it slowly than can be secured from a dryer that holds a small amount of fruit and dries it rapidly. With an un-

usually fortunate adjustment of temperature and air circulation, well cured prunes can be put through in a relatively short time, but in most of the dryers as they exist today, 36 hours is none too long.

Attention to temperatures is sometimes far from what it should be. It is not unusual to see one or two cheap thermometers used to indicate temperatures for a whole dryer. Occasionally these thermometers will vary 10 or even 15 degrees from a standard tested thermometer; this difference may be serious in its results. Furthermore there is often a considerable temperature difference between two adjoining tunnels or stacks, and while one tunnel or stack may be at the proper temperature its neighbor may be materially above or below it. Still further, the temperature indicated by a thermometer hung just inside the door where it may be read through a small glass window is often considerably different from the actual temperature of the fruit on the nearest trays. The possibility of reading the temperature without opening the door and thus disturbing the air circulation of a whole tunnel is a distinct advantage but a correction should be made for the reading of the thermometer.

The importance of a lively air circulation is not always sufficiently appreciated. It is true that heat is necessary to drive off the moisture from the fresh fruit and that the higher the temperature the more moisture is taken up by a given amount of air. But it is also true that a cubic foot of air will take up only a certain amount of moisture at any temperatures practicable in a prune dryer, and that a lively current of constantly renewed fresh air will take off as much moisture in a given time as a smaller amount at a higher temperature. In addition, rapid circulation at a rather low temperature produces better fruit. Great heat in stagnant air boils the fruit, making one of the causes of drip. When the current is slow, and the temperatures high, moreover, the air takes up its full capacity of moisture; as it progresses the length of the tunnel or stack it loses its heat and as a result some of its moisture holding capacity. This accounts for much of the moisture sometimes found on the fruit recently placed in the dryer. If the air leaves the lower end with only part of its moisture-holding capacity utilized, it can stand considerable cooling without giving up any of its moisture again. On the other hand, if the dryer must be crowded and fruit put through as quickly as possible, a higher temperature can be carried safely with a brisk circulation than is possible with a slow current. There is less drip and less scorching.

Cold air intakes should be numerous and located on various sides of the pit, so that a sufficient number may be kept open, regardless of the wind. Sometimes a high wind from an unfavorable direction will seriously cripple a dryer by making it necessary to close the cold air intakes. With these closed, very little air circulation can be secured.

The cold air intakes should be located at a lower level than the heating pipes; otherwise they will serve at times to draw out hot air rather than admit a cool supply.

The ventilators should be arranged with adjustable slides to regulate the size of the opening. A hood that can be set against the wind is very desirable to prevent the occasional backing up of circulation by strong gusts. Partitions for each stack or tunnel, extending at least part way up the ventilator, tend to keep the circulation more uniform throughout the dryer.

The fruit is generally allowed to cool before removal from the trays. There are many tools for removing it. One good utensil is the blade of an old hoe with the metal shank straightened to form a wide, flat paddle; wooden paddles are often used. The trays are usually emptied on benches near where the prunes are taken out, and from these the fruit is either sacked or taken to the warehouse. This should be in a separate building, if possible, located at a little lower grade than the dryer. In such case there are a number of means of conveying the fruit from the dryer. Cars mounted on fixed rails, boxes on wheels and wheelbarrows are in common use.

The weight of dried fruit secured from a given amount of fresh fruit is, of course, a matter of importance. Twenty pounds of dried product from a bushel of fresh fruit is the figure most commonly given. The extreme range is from 14 to 29. Much depends on the ripeness of the fruit, on the season

as it affects the sugar content, on the time and the thoroughness of drying. Most of these factors are discussed elsewhere in this paper.

A serious question confronting the man who is about to erect a dryer is the capacity he shall plan on. If his total prune crop will average 20 tons he may figure on an average drying season of three weeks and build his dryer to handle one ton per day. Occasionally, however, the crop ripens all at once and his drying season may be reduced to one week. In this case a dryer of treble the capacity would be required to handle the crop satisfactorily. The extra outlay involved in the larger dryer will be as great as would be involved by the occasional loss of part of a crop. Probably the wisest course is to build somewhat above the estimated requirements, then in an unfavorable-season crowd it as much as possible and charge the rest to profit and loss.

Care in the details of construction is likely to be rewarded. Large open cracks and loose joints permit large amounts of heat to escape without performing its function. In some cases the dryers are built on piling, exposing the pit, furnaces and floor to the sweep of the wind and often causing considerable derangement of the circulation. Tunnels and stacks should not be built close to the outside wall of the building; if they are, of necessity, so placed, a dead air space should intervene.

From Table III it is evident that the efficiency of dryers varies greatly, depending sometimes on the construction and sometimes on the management. The figures given were selected from the reports of dryers visited.

TABLE II.

Stack Dryers.

No. of stacks.	Capacity for 24 hours. (Bushels)	Total No. of men required.	No. of men per ton of dried fruit.	Wood used per ton of dried fruit. (Cords)	Cost of wood and labor per ton.
24	125	5	4	0.8	$10.40
24	100	4	4	1.0	11.00
24	200	6	3	1.0	9.00
18	90	4	4.1	....	....

Tunnel Dryers.

No. of Tunnels.	Capacity for 24 hours. (Bushels)	Total No. of men required.	No. of men per ton of dried fruit.	Wood used per ton of dried fruit. (Cords)	Cost of wood and labor per ton.
6	24	5	7.5	1.0	$18.00
7	100	6	6.0	1.0	15.00
7	150	7	4.6	0.66	11.28
3	150	4	1.3	0.66	4.58
3	120	4	3.3	0.6	8.40
5	125	4	3.2	2.4	13.60
5	250	6	2.4	1.1	8.10
16	175	6	3.4	0.85	9.35
12	500	10	2.0	....	....

These figures were selected to show the variation in results obtained with an equal number of stacks or tunnels. The original cost, interest on capital invested, and insurance charges are presumably the same on dryers of like construction; the table shows how the other charges vary. It is easy to see why some dryers are operated at a loss. An inspection of the figures will show inconsistencies so great as to be almost absurd. For instance, three 24 stack dryers are listed, no two of which are alike in capacity or in fuel and labor cost per ton. The six tunnel dryer apparently has slightly over half the capacity of one of the three-tunnel dryers and considerably less than half the capacity of the other three-tunnel dryer. The 16 tunnel dryer listed apparently turns out far less fruit than one of those having five tunnels; the

former uses the same total number of men as the latter, but more men per ton of output, at the same time using less fuel.

The figures from 50 or more dryers indicate that when proper management is given the larger dryers are more efficient. There is a tendency, however, with these larger dryers, especially when the management is indifferent to securing the greatest economy, to use superfluous help and to be wasteful in firing.

TABLE III.

Average Cost of Drying Per Ton of Dried Fruit.

Wood.	Labor.	Interest on Dryer.	Insurance.	Extras.	Total.
$3.40	$8.00	$6.00	$1.80	$0.40	$19.60

The cost of drying varies materially with the size of the dryer, cost of wood and especially the management. The figures in Table III are no more than an approximation of the ordinary cost of the operation, assuming a fair degree of efficiency. They are based on a dryer turning out one ton per day during a season of 20 days. Wood was figured at $3.00 per cord, labor at $2.00 per day, interest at 10%. The "extras" include such items as sorting, lye, and repairs necessary during a normal season. In some years this will be higher. It is interesting to note that the second largest expense connected with drying is one which few growers consider at all. The insurance will be a fairly constant figure for a given valuation, but the interest charge per ton will depend to a large extent on the capacity and output of the dryer. When the season is lengthened or the output increased by drying such other fruits as Loganberries, cherries, pears and apples (all of which can be dried in the same building) the interest charges per ton will be lessened by so much. This would also be true when the man owning a dryer with a capacity greater than his crop, dries prunes for other growers.

Fig. 21. Pears before and after drying.

It must be understood, however, that without considering interest and insurance, the majority of the prunes are dried at a cost of from $12.00 to $15.00 per ton. In some cases, with poorly constructed dryers, poor management, inefficient arrangement, labor poorly distributed or the firing wasteful, drying must cost as high as $22.00 per ton, without including interest.

Careful study of the figures from which Table II is taken shows throughout the same inconsistencies above noted. This means several things: First, it means that some men are running their dryers merely to get the moisture out of the fruit, regardless of quality, and are drying too much fruit in a day. Second, it means that there are many leaks in the management of the dryer, through help that is not always busy, through lack of attention to ventilation and temperature and through careless firing. Third, it means that some men are getting very creditable results, turning out good fruit from inexpensive dryers. It means also that the man in charge of the dryer is often a most important factor. It means, finally, that there is a considerable lack of uniformity in the output.

THE LOGANBERRY IN OREGON.

By V. R. GARDNER.

Introduction.

In nearly every section of the United States where a commercial fruit industry has been developed, small fruit growing occupies a more or less prominent position. Especially is this true in the newer fruit sections where it is often found very desirable to grow small fruits between the trees until the larger orchard fruits begin to bring in returns. In Oregon, at least, the small fruit industry is very important, ranking third only to the apple and the prune. The cane fruits, including the raspberry, blackberry and dewberry, nearly always occupy an important place among the small fruits. Their position in this state is especially prominent because they include the Loganberry, the Phenomenal, the Primus, and certain other raspberry-blackberry, or raspberry-dewberry hybrids. The fact is that very recently the first-mentioned of these hybrids has been coming to the front as one of the most important of the cane fruits in this part of the country, and apparently it is destined to occupy a still more prominent position. Inquiries regarding its habits of growth, soil and cultural requirements, yields and prices have been very numerous. There is little in print regarding it to which inquirers may be referred. Unfortunately there is at hand very little experimental data pertaining especially to the Loganberry that may serve as a basis for cultural recommendations. Still, because of the persistent demand for information on the subject, it seems desirable to bring together some of the facts that are known regarding the industry and the crop, and thereby make them available to the small fruit grower. It should be realized, however, that investigations that are now in progress and subsequent experience may render necessary modification of some of the practices that are here described.

Botany of the Loganberry.

The Loganberry, according to Shinn (1), originated in the early eighties in the garden of a Mr. J. H. Logan, of Santa Cruz, Cal. It is supposed to be an accidental seedling of the Aughinbaugh dewberry, one of the cultivated varieties of the western dewberry *(Rubus vitifolius)*. It is practically certain that the male parent is one of the European red raspberries, probably the Red Antwerp. In both plant and fruit characters, the Loganberry is intermediate between these two probable parents. Like both parents it is a perennial with biennial canes. The plant is semi-trailing in habit but considerably more erect that the western dewberry. The leaves resemble those of the male more closely than those of the female parent. The fruit is like that of the dewberry in structure but in both flavor and color more nearly resembles the raspberry. Like most hybrids the plant shows greater vegetative vigor than either parent. Coupled with this extra vigor is a correspondingly increased productiveness.

Cultural Range.

The geographical range of the European red raspberry *(Rubus idæus)* to which the Red Antwerp belongs, is Europe and Western Asia. The species is usually regarded as a reasonably hardy one. Red Antwerp itself is supposed to have originated near the city of Antwerp in Belgium, and is known to be able to stand considerable frost, 40 to 45 degrees at least. Like most fruits of European origin it does better in Western Europe and on the western coast of this continent than it does in the eastern and southern states. The variety is grown, however, to a limited extent in many of the states east of the Mississippi river.

The western dewberry is apparently found only in California, Oregon, Washington and parts of Idaho, and is completely at home only in the sections

(1) Garden and Forest for Nov. 21, 1894. Cit. by Bailey. Evolution of our Native Fruits. P. 358, 1898.

west of the Cascade and Sierra Nevada ranges. The cultivated varieties of this species are few in number and apparently have not been tried to any extent outside of the Pacific coast states. This species is to be regarded, therefore, as almost exclusively a Pacific Coast form. The fact that it ranges north to British Columbia, however, would indicate that at least some of its forms possess considerable hardiness. The Aughinbaugh, from which the Loganberry is supposed to have descended, does not apparently possess the hardiness of some of the more northern forms of the species.

From the geographical range of its two parents one might think that the Loganberry would be adapted to a wide range of territory, though it seems reasonable to suppose that it would be especially adapted to Pacific coast conditions. The fact is that it is much more susceptible to cold than either of its parents. Like the western dewberry it starts into growth very early in the spring and is very slow about maturing its canes in the fall. It is even slower than its parent in ripening in the autumn. In fact, it can hardly be said to ripen its canes. Cold weather simply checks its growth; mild weather during the winter season enabling it to continue growing. This makes it practically out of the question to grow the Loganberry in regions or sections where there are severe winters. Winter temperatures of 0 F. or even of 10 F. are very apt to injure the canes. Especially is this true if some form of artificial protection is not afforded. Numerous attempts have been made to cultivate the Loganberry in the northern and eastern states, but they have usually resulted in more or less complete failure. Even with good winter protection, low temperatures often kill back the cane growth to the ground and sometimes kill the plants outright. Little has been done in the southeastern and south-central states in the way of trying out this excellent fruit. At the present time its culture seems to be limited to the western parts of the states of California, Oregon and Washington, and apparently it does better in the two latter states than it does in the former. It seems to require not only a mild winter but a long, cool and moist summer for reaching its best development; consequently it is the coast regions and the valleys like the Willamette, Umpqua and Rogue River that are most suitable for the commercial culture of this fruit. As one goes south in this range it is found that the plants are somewhat less productive and the berries themselves somewhat smaller than in those sections further north where moist, cool summers are the rule. The highest altitude at which the Loganberry will thrive is not known. High altitude, however, provides conditions much the same as northern latitudes and in general it may be said that the plant does its best at comparatively low altitudes.

Development of the Loganberry Industry.

Almost from the first the Loganberry has been regarded as an excellent fruit for the home garden. Though soon after its introduction small quantities found their way into local markets, its soft texture made it a poor shipper and a large commercial Loganberry industry has been slow to develop. It is only within the last few years, in fact, that what might be dignified by the term "Loganberry industry" has been developed. The first gradual expansion of the industry was due mainly to the increasing size of the local markets and to the increasing popularity of the fruit. It was not until the fruit began to find its way upon the market in the form of by-products, however, that a great impetus was given the industry. A five-acre field of Loganberries was considered a large planting five years ago; now a 20 or 25-acre area is not regarded as especially large and some much larger fields are being established.

Loganberry Sites and Soils.

Like related plants belonging to the raspberry, blackberry and dewberry groups, the Loganberry may be grown upon a large variety of soils and under widely varying conditions. Productive plantations are often found on heavy clays, and only a short distance away equally productive plantations may be found on very light sandy soils. In general, however, a soil that is somewhat intermediate in character is much to be preferred. Rich, deep loams that have

enough clay to make them reasonably strong and at the same time enough humus and sand to make them fairly loose, open, porous and easily worked, are to be preferred. With the Loganberry it can be said that the richer the soil the better. It is true that very rich soils afford a very strong, vigorous and even rampant growth, but when planted at the proper distances on these lands and suitably pruned, the plants are exceedingly productive. The question is often asked: "Are hill lands more suitable or less suitable than valleys or river bottom soils?" Not so much depends upon the exact location of the land or its slope or elevation, as upon the texture, depth and quality of the soil. In selecting river bottom or valley lands it is important to see that they are well drained. It is not necessarily harmful to have the land overflowed for a short time during the winter, but water should not stand on it for any great length of time during the winter, and water upon the land in the spring when growth is starting is not to be tolerated. That good drainage is as essential to a good growth of the Loganberry plant as it is for practically all other fruit plants, should also be borne in mind when planting on hill land, for such lands are often far from being well drained. The particular slope or exposure on hill lands is a matter of little importance in the case of this fruit—at least of less importance than with many other fruits. It blooms very late and is not apt to be caught by late spring frosts even though the field may be on a south slope and therefore forced into bloom a little early. The main advantage in having a northern or eastern slope lies in the fact that they afford a certain degree of protection from the heat of the sun; the slightly lower temperature and moist atmosphere and soil will tend toward affording a little longer picking season and probably a little heavier crop. For this same reason river bottom soils are often preferred to the hill lands. In extreme cases this difference may amount to two weeks in length of picking season and from one to two tons of fruit per acre in yield. Southern slopes where the soil is thin, and lands anywhere which have an impervious layer close to the surface, are to be avoided for the Loganberry. The so-called "white lands" are very poorly adapted to it. The same may be said of very light soils which require heavy applications of fertilizer in order to grow the cane fruits at all.

Propagation and Planting.

The Loganberry is propagated by means of rooted "tips." In this respect it resembles its dewberry parent. The ends of the new canes take root during the winter or in early spring and one of the regular axillary buds in the region of the rooted portion of the cane develops into an "eye." From this "eye" a strong, erect shoot is soon produced; this shoot, together with its roots, constitutes the "tip." Theoretically, each cane should produce at least one rooted "tip." Practically each cane does not do this, for many do not happen to lie where the soil is soft enough for them to take root, or they may be prevented from rooting by some mechanical obstruction. The more loose, porous and friable the soil, the larger will be the number of "tips" that may be secured per plant. Not only do the ends of more of the canes root in loose soil, but rooting is accomplished earlier in the season, and, as a consequence, larger, stronger plants are obtained at planting time.

If large numbers of "tips" are desired, the shoots may be "stopped" by pinching when three or four feet long, and each made to throw out several laterals. The ends of these laterals usually root as readily as the ends of the main canes and make just as good plants. Where soil conditions are rather unfavorable for rooting of "tips" the process may be hastened and made more certain by drawing a little soil up over the ends of the canes.

The income per acre that may be derived from selling tips from the regular commercial plantation often amounts to a considerable sum. Even on very ordinary land and without artificially covering the tips of the canes, from 1,500 to 2,000 new plants per acre often may be obtained. When an effort is made to secure as large a number of "tips" as possible, from 3,000 to 5,000 per acre are not uncommon. With prices ranging from $10.00 to $20.00 per thousand, this means an income of from $30.00 to $100.00 per acre from this source alone.

It is the general practice to set the "tips" immediately in the permanent plantation where they are to fruit, though some growers prefer lining them out in the nursery row for one year and then transplanting the one-year-old plants to their permanent location. There are arguments both for and against either procedure. Setting the tips immediately in their permanent location saves the labor of transplanting but for the first year uses more land than the young plants actually need. Which method will be the more satisfactory will probably depend upon whether land or labor is relatively the more costly.

Planting is usually done in the spring. This is necessarily the case if new "tips" are employed. If one-year-old plants are available, either fall or spring planting may be practiced, whichever is the more convenient. It is not known that the one season is better than the other for average conditions. The main thing to avoid is too late planting. If planting is delayed until after most of the spring rains are over, the plants may suffer from drouth and be slow in starting.

It is considered good practice to set Loganberries rather deep. The crown of the "tip" as it is lifted from the field is usually just about at the surface of the ground. This should be set three to five inches below the surface. In planting it may not be well to fill in immediately with soil above the crown to the general level of the land, but leave the planted "tip" in a depression. Gradually this depression will become filled until the level of the soil immediately about the plant is the same as that of the field in general. Experience shows that Loganberries planted deep in this way are longer lived and make stronger, thriftier plants than when set shallow.

As to distance for planting, practice varies considerably. If the soil is not very rich and only a moderate or rather weak growth is to be expected, 6x8 feet will be far enough between plants. On very rich, deep, river-bottom soils, 8x10 or 8x12 feet is none too great a distance. The trellis is usually so constructed that the distance between the plants in the row is greater than that between the rows. Considerable difference of opinion exists as to whether it is preferable to have the rows run north and south or east and west. Probably the berries will be more evenly distributed on the two sides if the rows run north and south. If they run east and west a larger percentage will usually be borne on the south side. Topography of ground and shape of field will largely determine direction of the rows.

Tillage.

The cane fruits in general require thorough cultivation and the Loganberry is no exception. Unlike its parent, the red raspberry, it is not prone to sprout, and consequently cultivation may be fairly deep, especially if the plants have been deeply set. In some soils it is advisable to use a one-horse plow between the rows in the spring to break the ground, following this with the ordinary tools for fining the soil. Cultivation should be continued until well after the crop is harvested. It is usually necessary to do some hand hoeing immediately around the plants and in the plant row.

Cover Crops.

Artificial cover crops are seldom grown in the small fruit plantation. It often happens, however, that chickweed or some other wild growth comes up and makes a natural ground cover. Weed growth of this kind, late in the season, should be welcomed. for without doubt it materially benefits the soil through the addition of organic matter. To what extent it would pay to grow artificial cover crops where natural ones do not come in, is an open question. It would seem, however, that it might be desirable in soils that are inclined to be very heavy or very light.

Fertilization.

It may be frankly admitted that very little is definitely known regarding the fertilization of cane fruits in general and that still less is known regarding the specific fertilizer requirements of the Loganberry. For the most part loganberries have been grown upon new, rich soils that have not yet had their

fertility seriously depleted and little attention has been devoted to the subject of fertilization. It is known that they do better in rich soils than they do in soils of a poorer grade. What elements are especially required by the crop, however, can be only a matter of conjecture. In a general way it may be stated that probably the same principles apply to the fertilization of the Loganberry as to many other fruit crops. Until more is known regarding the principles underlying soil fertility in general and the fertilization of our fruit plants in particular, one is hardly warranted in making any specific fertilizer recommendations for the Loganberry.

Irrigation.

In Oregon, at least, the Loganberry is very seldom irrigated. It is not grown commercially in those sections of the state where irrigation is generally required. This is probably due less to the moisture factor than to that of temperature. From the fact that it seems to do its best in the coast counties where the rainfall is very heavy, and that even in those parts of the state, such as the Willamette Valley, where the rainfall is moderate, it does its best on deep and moist soils, the inference might be drawn that irrigation might be employed to advantage under some circumstances. What its actual moisture requirements are in different soils in order to provide for a maximum production, and at what stages of growth water can be applied to best advantage, are questions that need investigation.

Trellising and Pruning.

As has already been suggested, some kind of trellis is necessary in order to hold the fruiting canes off the ground. When only a few plants are grown for home use, many different methods of trellising are used. In commercial plantations a two or three wire trellis, such as is employed with American grapes, is most commonly used. If two wires are used they are stretched about three and four and a half feet, respectively, from the ground. If three wires are used they are strung at about three, four and five feet from the ground. Occasionally they are strung on the ends of 18 or 24-inch cross bars that are fastened to the posts about four and one-half feet from the ground. This system of training, however, is apparently less satisfactory than having the wires directly above each other. It takes up more room and it is a little more awkward to pick the fruit than when the other system is used.

The shoots of the Loganberry are erect or semi-erect until they become one or two feet long, when their weight bends them to the ground, and they trail closely along its surface for the rest of the season. In good soils and during a good season these shoots frequently become 12 or 15 feet long, sometimes longer. In order to keep them out of the way of the cultivator, and also from being tramped on and injured by the pickers, they should be directed along the row and thus made to spread in only two directions from the parent plants. Generally it will be found advisable to use two or three small stakes or pegs between each two plants in the row, to keep the new shoots from spreading over the ground. These are set on opposite sides of the row and about 18 or 24 inches apart and the canes made to lie between them. This plan of training the growth of shoots in but two directions serves also to bring them close together where they will afford each other a certain degree of protection from severe weather in winter. Furthermore, should any artificial covering be necessary they are in such a position that it can be most easily and economically applied.

As soon as the growth starts in the spring, the canes that grew the season before should be taken up and tied to the wires. It is generally necessary to cut them back to six or eight, or at the outside, 10 feet in length. If this is not done the canes from one plant will overlap those from the neighboring plant and too much brush will come at one place along the trellis. Many go to the trouble of separating the canes, leading one or two along each wire in each direction. Others simply lead about half the canes from the plant to the upper wire and fasten them along it and the other half to the same wire in the opposite direction. Some growers make a practice of leading all of one season's growth

VARIETY ADAPTABILITY.

By C. I. LEWIS.

There is probably no problem of greater importance to the fruit grower of Oregon today than that of variety adaptability. No matter how good a location he may have for an orchard, no matter how intelligent the care of the orchard may be, if he has chosen varieties that are not adapted to his conditions, he will be doomed to failure, or at least must be satisfied with very ordinary returns. The Division of Horticulture of the Oregon Experiment Station has undertaken the task of trying to solve for the people of Oregon this problem of variety adaptability Every member of the staff has given more or less attention to this problem and we are hoping that every fruit grower will co-operate with us along this line of work. We should like to have a large number of fruit growers keep weather records for the entire growing season, since we feel that after all there may be a very close connection between climatic conditions and the successful growing of certain varieties.

This state has tried to solve the problem of variety adaptability altogether too soon. In the early days many of the orchardists planted 40 or 50 varieties. This undoubtedly was a mistake, and most fruit growers soon learned that it is much better for a single orchardist to grow only three to five varieties. On the other hand, where the greatest mistake seems to have been, was when whole communities or sections, and, in fact, the entire state, concentrated on only two varieties, Spitzenberg and Yellow Newtown. While these have done well. unusually well in some sections of our state, nevertheless the state as a whole is not especially adapted to these varieties.

There are a great many kinds of fruit that are well known to the commercial world and almost any variety of apple, peach, pear or cherry, for example, finds a ready market in some quarter of the world. It was a decided mistake to graft over all the trees in the community to two or three varieties. I am satisfied that some sections, even like Hood River, tried to settle this variety problem too quickly. If a man hears of a splendid sale of fruit of a given variety, he immediately concludes that that is the variety for him to plant, regardless of whether or not his natural conditions are suited to the variety. If there is any single region in the United States which indicates that it is adapted to many varieties of fruit, it is the northwest. If one but stops to consider that within this state great extremes of climate, elevation, soil, and general natural conditions prevail, it is only reasonable to conclude that the range of varieties would be extremely wide. In the matter of rainfall, for example, along the coast there are records of 130 inches annual precipitation, although the normal is about 70 inches. On the other hand, some sections at times receive as low as only two to three inches. In portions of Oregon from seven to 10 inches of rainfall annually is about as much as can be expected. Elevations range from sea level to the frost line. Soils vary from the heaviest adobies and clays to the lightest volcanic ash and pumice stone. Many graduations and types are found, very often in a relatively small valley. There is a wide variation in the length of the growing season in various parts of the state; such differences concern mean temperatures, extreme heat in summer and cold in winter. The suddenness with which the growing season terminates and winter weather sets in varies greatly. The average Oregonian is sufficiently familiar with the state to make it unnecessary for me to go into details concerning the localities in which these various extremes are found. Probably all of them have considerable bearing on the question of variety adaptability, some far more than others. Some varieties, moreover, are very exacting in their requirements, while other varieties will grow under many varied conditions. Rome Beauty and Wagener apples, for example. will be found growing successfully under more varied conditions than any other two varieties. Climate seems to have a marked influence on fruit as regards its maturity, size, color, etc. The Gravenstein, in Western and Southern Oregon, is largely a September apple; along the coast it seems to be of better keeping qualities, but when grown in the eastern part of the state it becomes a winter variety.

The question which we are all interested in more than anything else, is what is the factor, or what are the factors, which really control variety adaptation. I have already enumerated what we believe the principal factors are. The average man is apt to think that soil conditions are the only thing to consider in choosing a variety. Our investigation seems to indicate that while the soil may be a very important element under certain conditions, it is not so apt to be the controlling factor as some others which are worthy of consideration. The first item is that of climate. Under climate we would consider summer temperatures, mean temperatures, and extremes of heat and cold. The summer temperature seems to bear a close relation to the moisture content of the atmosphere, and these two factors taken together become strong limiting factors in variety adaptation, regardless of what the soil and other conditions may be. We find that Baldwin and Northern Spy apples, for example, do especially well in Western New York, perhaps better than in Eastern New York, or in the greater portions of the Pacific Northwest. Spitzenbergs and Yellow Newtowns do especially well along the Hudson river and in the eastern regions of New York, and succeed in almost any portion of the northwest where similar conditions prevail. Members of the Winesap group do well in Virginia and in the Carolinas and seem to do well in those portions of the northwest which more nearly approach the eastern conditions under which the varieties originated. Such regions, for example, are Wenatchee, Freewater-Milton and others, which produce Winesaps to a high degree of perfection. When we encounter different climatic conditions such as prevail west of the Cascade range, the Winesap becomes quite a different apple; it grows smaller, has a poorer color and does not have the same commercial rating. In all probability the mean temperatures are too low, and the nights too cool, to grow the Winesap successfully. We find that the Ben Davis group must have special requirements if they are to succeed, and that their northern limit of growth is soon reached.

Some recent work done by Dr. Shaw, of the Massachusetts Agricultural College, shows us that it may be possible to determine variety adaptation by working out the mean temperature during the growing season. Some varieties of apples are confined to a very narrow limit of temperatures. He found that the Ben Davis group did not do well unless grown with a mean temperature of 63 degrees. If it averaged lower than this the apples did not reach their highest degree of perfection.

Varieties of apples like the Winter Banana and Delicious seem to do better where the seasons are shorter, altitudes higher, nights cooler and the temperatures in the middle of the day fairly warm. The fall and early winter temperatures are often a determining factor, as some varieties do not go into the dormant period easily, but tend to continue growth and run to wood rather than to develop fruit. In these localities where winter comes on abruptly we find that many varieties like Spitzenberg and Yellow Newtown do not do well; varieties like the Wealthy and McIntosh are far superior. This is one of the few cases when Rome Beauty and Wagener do not do well, since such varieties are easily winter-killed before the trees are hardened. On the other hand, Rome Beauty will stand heavy frosts and will not shed its fruit as badly as many of our late varieties. Frost during the growing season affects most varieties. Some withstand these conditions better than others.

From observations which we have made we feel that the average moisture content of the atmosphere is going to play an important part in variety adaptation. The amount of transpiration which takes place in a plant will bear a close relation to its development.

The rainfall becomes a very important factor. In regions of low rainfall, if irrigation is impossible, it will be absolutely out of the question to grow certain varieties successfully. The fruit is very small, highly colored, but dry and corky. Rain at times tends to interfere with the proper development of the fruit, causing the cherries to crack in June and the prunes to do the same in September. Rain also sometimes interferes with the proper coloring of certain apples, especially during excessively wet seasons. Southern exposures are

sometimes necessary for small fruits to develop a high color and are very essential for the development of sugar in grapes.

Altitude is very important and bears a very close relation to temperature. Ordinarily varieties find a longer growing season in the lower altitudes and mature earlier. We find that Spitzenbergs in some of the lower valleys are at their prime by Thanksgiving time, but when grown at higher altitudes mature later. This is especially true in regions of the Inland Empire but not so true in regions west of the Cascade mountains, or those which extend to the west. As regards altitude in its relation to individual varieties, we have noted that in the Rogue River Valley, Yellow Newtown matures earlier by nearly a month at an elevation of 1,000 feet above the valley floor. The time at which it matures throughout the valley floor itself is sometimes influenced by the type of soil on which it is growing.

In choosing a variety we must give consideration to the soil, the important points being drainage. general fertility, and, at times, type, that is, the influence of clay, sand, silt or volcanic ash on the coloring and development of certain varieties. We know, for example, that Spitzenberg, if put on a poor soil, becomes weak and sickly, but when put on extremely heavy soil the tree becomes vigorous, but it is not so often productive, nor is the color of its fruit so high. If one can get a soil which is not too heavy, is abundantly supplied with food and moisture, provided the altitude is not too high, the Spitzenberg will probably succeed. On the other hand, the Gano seems to do well on some soils that have proved too thin and poor for many of our commercial varieties. The Northern Spy, if placed on very heavy soil, is late in coming into bearing. The Yellow Newtown often shows some of the same characteristics.

West of the Cascade mountains, especially, the amount of moisture which the soil holds in a very important factor. Certain varieties unless they have an abundance of moisture become very corky and dry and drop badly, are troubled with calyx cracking, and show other imperfections in the fruit. On the whole, pears seem better adapted to regions west of the Cascades than east of them. This is largely due to the growth which the tree makes and the ease with which blight can be controlled. Those portions of Eastern Oregon with a rainfall of 17 to 20 inches seem to grow pears better than those of less rainfall.

Varieties of fruit which we especially recommend for the state were given in Bulletin 111 of this station. Since that time new observations have been made and we hope that from year to year we may be able to determine definitely the best varieties of those that have been tried in the various horticultural districts of the state. In order to have this work of the greatest value, it should be carried on over a series of years, so as to determine the influence of climatic changes; since a given season may not be typical. This was true this past year. Throughout the state there was present much more moisture during the growing season than can be expected in a normal season.

Special observations were made, however, in some of the coast districts, in the Willamette Valley, in portions of Eastern Oregon at Freewater-Milton, and in the Grande Ronde and John Day Valleys.

In the Grande Ronde Valley, in Eastern Oregon, the Rome Beauty and York Imperial seem to have been on the whole, the two best varieties. The Rome Beauty has shown up especially well. The York Imperial is undoubtedly a very splendid apple for that district but to be of the highest type it needs much more thinning than the average grower is giving at the present time. The Rome Beauty has withstood fall frosts very successfully. At Imbler, which is known as the Sand Ridge country, Yellow Newtown, Wagener and Gano seem to be the leading varieties. The Yellow Newtown throughout Eastern Oregon did much better this year than formerly. It may not be safe for us to conclude that we can recommend this variety highly until it has been given further trial. The Jonathan, to our mind, is a poor variety to grow in the Grande Ronde Valley. It has a tendency to become very small, of poor color and is often extremely angular. This is true also of the Grimes Golden.

In the Union district the Rome Beauty, York Imperial, Red Cheek Pippin

and Rhode Island Greening were the most promising, while in the vicinity of La Grande; Rome Beauty, York Imperial and an apple locally known as Oregon Red Winter were the leaders.

In the higher altitudes of the Grand Ronde country the Winter Banana and Delicious have done exceptionally well when not irrigated, but when grown at lower altitudes and irrigated they were not so promising. On the higher portions that are non-irrigated we believe it poor practice to grow such varieties as Spitzenberg, Jonathan and Grimes.

In the John Day Valley, Gravenstein and Grimes were both doing well. Gravenstein seems to be at its prime the middle of October. Rome Beauty, Rhode Island Greening, Northwest Greening, Red Cheek Pippin and Yellow Newtown all did well this past year.

The Freewater-Milton district, which is a part of the Walla Walla Valley, is readily divisible into three sections, the Walla Walla river canyon, the gravelly districts and the sub-irrigated districts. In the Walla Walla river canyon the Rome Beauty, Newtown and Red Cheek were the three best varieties. The Jonathan and Winesap were grown to a certain extent but were lacking in color and often of small size. In the gravelly district the Winesap seems to be the best apple, the Jonathan second, and the Rome Beauty third. Other varieties that were grown but that did not succeed quite so well were Yellow Newtown, Grimes, Spitzenberg and Red Cheek. On the sub-irrigated portions of the valley the best variety was Rome Beauty. Other varieties that were doing well were Arkansas Black, Jonathan, Winesap and York Imperial. Spitzenberg and Red Cheek Pippin were doing well in places. There was a tendency, in the sub-irrigated districts, for the apples to water-core, more so than was observed in other sections of the valley. All in all, we would say that the best varieties for the entire Walla Walla district would be the Winesap, Rome Beauty, Jonathan and Grimes. The only criticism of the Rome Beauty would be that we think it tends to mature somewhat early.

On the Hermiston project some of the young apple trees began to bear this past year. The Winesap and Rome Beauty are both very promising. The fruit was of good size and splendid color. Winesaps grown in this section will keep well, from present indications.

More inquiries are sent to this station requesting information regarding the best varieties to grow in the Willamette Valley than for all other sections of the state combined. This is due partly to the fact that there has been a great renewal of horticultural interests in this section and that there are relatively few commercial apple orchards in bearing. The old home orchards are generally not a fair index of what may be expected from commercial plantings. The problem of what varieties to grow is a very hard one to solve, owing to the fact that the valley is large and has many diverse conditions. No solution can be arrived at until more orchards have come into bearing. Certain portions of the valley are demonstrating that they have answered, to a certain degree, the variety question; but other portions of the valley as yet are unable to determine which varieties will be most successful. While we can recommend generally for the entire valley, nevertheless it is somewhat unreasonable to expect that three or four varieties can be selected that will do well in all sections of a valley of such extremes. Among the varieties that have shown the greatest commercial possibilities the past season are Grimes Golden, Rome Beauty, Gano and Jonathan. Of the varieties of green and yellow apples grown in the valley, I believe the Grimes Golden is by far the best. It tends to be a regular bearer, grows to good size, is especially free from blemishes and produces relatively few culls. In many sections of the valley this apple seems to be doing unusually well. The Red Cheek is a green variety which, I believe, should be grown more extensively. While it is true that the trees are often of poor vitality, when they are given proper treatment they make a good growth. This variety will require more pruning in order that better color will develop. The Yellow Newtown, one of our leading varieties, will probably always tend to be affected by the scab and the growers of this variety will have to make up their minds to combat this disease. While the Ortley has not been grown extensively, what few trees

have been observed were very promising. Of the red varieties, Rome Beauty shows promise of becoming the leader. Gano in many sections has done well and is far superior to Ben Davis, which has too many culls and lacks uniformity. Jonathan is very highly recommended by some growers. In the foot hills this variety seems to develop unusually well, is a good keeper, and generally of fairly good color. In some localities Jonathan does not do sufficiently well to be of commercial standing. Gravenstein does very well in the valley as a whole, Gravenstein and King being the two best fall apples produced in this section. In portions of Yamhill county King is doing unusually well. Spitzenberg, generally, is losing favor, but in the Salem district many of the growers believe it to be one of the best money makers. Wagener is being grown as a filler; while as yet few trees are in bearing, those which are, are promising. Northern Spy in the foot hills, where it does not overgrow, is doing unusually well. The best Spys we have found in the state were from portions of this valley. In the northern part of the valley, in portions of Washington county, near Banks, the Northern Spy is doing very well. In Columbia county the Yellow Transparent, the Northern Spy, and Hubbardston have demonstrated their value for that section. While Chicago is an apple of some importance in Columbia county, it needs to be tested further before we know definitely its true value. In Benton county Vanderpool Red is meeting with great favor, and some of the growers in other sections of the valley believe this to be the best commercial variety. It is a splendid keeper, a good shipper, and tends to be an annual bearer. It has a bright red color but is heavily blotched with russet around the stem. In many orchards it runs rather small, but where proper thinning is practiced the size is greatly improved. Quite a few of the orchardists in Benton county are planting extensively to this variety. It is supposed to be a seedling of Spitzenberg.

During the past two seasons careful observations have been made on pear growing in this valley. There is great promise for the future. Bartlett, Bosc, Glout Morceau, Anjou and Clairgeau are especially successful. Bosc is doing remarkably well and unexcelled in size and quality by any Bosc we have ever seen.

A great many inquiries are sent to the station concerning the possibilities of growing fruit in the coast counties. We have attempted the past few years to make some observations in those sections. Gravenstein and King seem to be the two best varieties so far observed. We have been surprised frequently by the remarkable color that has developed on some of these apples. The finest color that I have ever seen on Gravensteins was found on some from that section. Last year among the best King of Tompkins county sent into the Station were specimens from the coast regions. It will probably be some time, however, before we know definitely the best apples to grow in that section. The indications are that berries, especially the brambles, should be grown extensively. Canning factories should be established, when a splendid paying business could be built up on small fruit production.

BUD VARIATION IN RELATION TO FRUIT MARKINGS.

By E. J. Kraus.

During the progress of studies on the pollination of cultivated fruits, attention is frequently called to certain curiously banded or striped fruits which occur more or less commonly. As examples, one may mention the Esopus (Spitzenberg) apple, which very frequently exhibits a pure yellow band of varying width extending from calyx to stem, or the Ben Davis, which often shows a similar band of deep red. Many other varieties manifest this same peculiarity in various colors, or in bands of russet.

Many explanations of this phenomenon have been offered. Chief among these may be mentioned the secondary influence of pollen. The occurrence of these bands on fruits has been used by many, in fact, as one of the strongest arguments in support of the theory that color in the pome fruits may be directly influenced by the pollen concerned in the fertilization processes. In other words, if Esopus (Spitzenberg) were pollinated with Baldwin, the fruit resulting from such pollination would be uniformly of a deeper red color than if Yellow Newtown pollen were used. Xenia has been offered as an explanation. It could not possibly be called Xenia, however, from the very definition of that term as given by the latest authorities. Coulter and Chamberlain (1) sum up this subject by saying: "The phenomenon of Xenia has a direct bearing upon any discussion of the endosperm. * * * So far as definitely known, the effect of foreign pollen outside of the embryo is observed only in the endosperm, as first pointed out by Körnicke, and this has been most clearly established in the crossing of races of corn. It also appears that this influence of foreign pollen extends only to the color of the endosperm and the chemical composition of the reserve materials, the size and form of the kernels remaining unchanged, as stated by Correns."

In an attempt to determine how generally the occurrence of this striping had been observed and what might be the explanation, inquiry was made of more than a hundred leading horticulturists and botanists. The replies were extremely varied, the most general explanation being on the basis of a secondary influence of pollen, though a number inclined toward some form of bud variation as a solution.

While this matter seems of small importance at first, nevertheless it bears on an important problem. If it could be shown that pollen of a dark-colored fruit would intensify the color of another fruit when crossed upon it, or, on the other hand, if a light-skinned pollenizer would tend to dilute or lighten the color, then by all means must care be exercised in selecting pollenizers in commercial orchards. In effect should it be desired to plant an orchard of Esopus (Spitzenberg), to secure finely colored fruits there must be planted with it for a pollenizer some dark-skinned variety, such as Arkansas Black, Baldwin, or Gano, but under no circumstances Yellow Newtown, Ortley, or Grimes, though from a commercial standpoint the latter might be much more desirable, because of their high quality, productivity or ease of production.

With these points in mind, experiments were begun in the best fruit-growing districts of Oregon. The idea was to determine whether or not the color of either Esopus (Spitzenberg), or Yellow Newtown could be changed by the variety of pollen used. These two varieties were crossed and reciprocal crosses made. In addition to the Newtown and Esopus (Spitzenberg) pollen, the following varieties were used: Arkansas Black, White Winter Pearmain, Baldwin, Ben Davis, Monmouth (Red Cheek Pippin), Winesap and several others in smaller numbers. These were intercrossed, dark on dark, light on light, light on dark and dark on light. All ages of trees from four to 25 years old were used. Several kinds of pollen were employed on the same tree and in different parts of that tree, so that some would be exposed to full sunlight and others would receive none. Trees on various soil types were selected, and, as already indicated, under different climatic conditions, such as obtained in the Rogue River, Willamette, Hood River and Walla Walla Valleys. In other words, as many factors as possible that might affect the color of the fruits, were brought into the experiment, and the effect of various kinds of

pollen on the various varieties was also tested. From hundreds of crosses made during each of three successive years we are forced to conclude that color in the immediate cross is not directly influenced by the kind of pollen used. Soil conditions, vigor and age of trees, moisture supply, exposure of the tree and fruit to sun and air, are all important factors influencing color; far more so, indeed, than the kind of pollen used. It is absurd, of course, to deny that there is any secondary influence by pollen, but the color of the fruit of the pollen-producing parent is in no way shown in the flesh or skin color of the immediate cross. Even the frequently cited case of Indian corn falls in this class. As has been shown by Webber (2) and others, the color is limited to those parts which have developed directly from the sex cells and are visible merely because of the transparency of the fruit coverings and not due to any change in the color of those coverings themselves.

It may be well to mention in this connection the change in sugar content and flavor in certain seedless parthenocarpic or self-fertilized fruits, as noted by Ewert (3) and Müller-Thurgau (4). I have noticed, often, that the tiny seedless berries frequently observed in bunches of grapes are more highly colored and much sweeter than some of the others in the cluster. We must consider such seedless fruits as abnormal at best, and not serving to show the effects produced by *different kinds* of foreign pollen. At the Station grounds Oldenburg apples produced with no pollen whatsoever were in every way normal except that they were seedless and smaller than the cross pollinated fruits on the same tree. That there is a possibility of changing the size and shape of a fruit in the immediate cross, there can be no doubt. These factors are dependent, however, upon the vegetative vigor of the fruit which is almost without exception distinctly modified by the presence or absence of seeds. The seeds, in turn, except in very rare instances, are absolutely dependent on pollen for their development.

If we have an exceptionally strong or acceptable pollen, therefore, more or better seeds will be formed than if the reverse were true, and as a final result there will be a distinct change in the size or shape of the fruit itself.

Now in the case of the apple, or any of our fleshy fruits, of which, according to our latest morphologists, the torus or receptacle forms the major conspicuous portion, it is next to impossible to conceive that any part of the pollen enters into the formation of the flesh, except that by fertilizing the ovules a resultant stimulation produces a further development of the fruit. As a matter of fact, what is to become the edible conspicuous portion is already well formed before pollination occurs, and by no means can any part of the pollen tube or contents come into contact with the skin cells. The only possible chance for any effect on the color in the immediate cross must be through the influencing of the color characters already present in the tissue of the fruit. Such an occurrence is exceedingly unlikely and could only take place if some stimulating agent were transmitted from the seed to the somatic tissue of the surrounding carpels and thence into the remainder of the fruit. Certainly, regarded in the light of present day research, this is highly speculative and practically impossible.

The manifestation of color in pome fruits is dependent upon many factors, such as soil, exposure, elevation, etc., as pointed out above. Thus, frequently while certain elementary characters for color may be present, they may be suppressed because of the lack of conditions to cause them to become evident, or they may be truly recessive to some dominant elementary character and become evident only when this character is suppressed or removed. Since we cannot account for the abrupt banding or striped appearance in the skin of certain of our fruits as the secondary effect of the pollen, we must conclude that this color character is already present and that it is only allowed to exhibit itself by the suppression of the dominant character which masks or obscures it; or the reverse, when the recessive character which dilutes the dominant is suppressed or removed, the dominant appears pure. In other words, there is a somatic segregation of the color characters. We may term this segregation, if we choose, bud variation. It is at best a loose term and has been used to cover any abnormal growth or sudden appearance of a so-

Lawver. Spitzenberg. King.

Spitzenberg. Ben Davis. Rambo (?). Yellow Newtown.

Upper figure:
- Lawver.
- Spitzenberg. Note the bands of pure red, pure yellow and the normal red surrounding them.
- King. The deformity is due to aphis injury; also poorly colored.

Lower figure:
- Spitzenberg. Normal color and yellow band only present; the most frequently occurring condition.
- Ben Davis. One half is pure deep red without indication of stripes.
- Rambo (?). (The specimen is somewhat deformed and small.)
- Yellow Newtown. One half is red and prominently striped.

Three-color blocks from Autochrome plates.

called abnormal character in a plant. In many instances, if we called such banding bud variation, we must limit it to variation of but a single flower; for it has been observed that a banded apple and a normal specimen may be borne on the same spur. The possibility of flower bud variation is certainly conceivable if we concede that morphologically a flower is a modified branch or strobilus, or that both branch and flower are modifications of a common ancestor.

Recent work by Hedrick and Wellington (5) on the breeding of apples tends to confirm the correctness of the conclusion of a somatic segregation of characters as an explanation of the banding af apples. From observations made on the progeny of certain varieties they have determined those elementary color characters which are carried by the skin of the parent, and which impart to it its characteristic color. In every instance in which they have made observations from breeding experiments, and I have received banded specimens of the same variety, the conclusions are the same. They list a number of which I have not seen banded specimens and I add some which they have not listed.

Conclusions from Breeding by Herrick and Wellington.

Variety.	Skin color carried.	Variety.	Skin color carried.
Ben Davis	Red, red.	McIntosh	Red, yellow (?)*
Esopus (Spitzenberg)	Red, yellow.	Mother	Red, (?).
Green Newtown	Yellow, red.	Ralls	Red, red (?), yellow (?).
Northern Spy	Red, yellow.	Sutton	Red, yellow (?).
Jonathan	Red, red.	Rome	(?).
Lawver	(?)		

*I have never seen any yellow in a banded specimen, though it may be found when more specimens have been examined.

Our Conclusions from Banded Specimens.

Variety.	Colors indicated by bands.	Variety.	Colors indicated by bands.
Baldwin	Dark red, light red, bronzy red, green, russet.	Lawver	Dark red, green.
		McIntosh	Dark red, light red (striped).
Ben Davis	Dark red, light red, (striped).	Monmouth (Red Cheek Pippin)	Green, bronzy red.
Cox Orange	Yellow, russet, light red (striped), dark red.	Northern Spy	Red, yellow.
		Rambo	Red, yellow.
Delaware Red	Light red, dark red.	Rome	Dark red, russet, light red (striped).
Esopus (Spitzenberg)	Dark red, yellow, russet.		
Gano	Dark red, light red (striped).	Salome	Dark red, light red (striped).
Golden Russet	Russet, dark red, yellow.	Shiawassee	Dark red, light red (striped).
Gravenstein	Yellow, dark red.		
Grimes	Yellow, green.	Winesap	Dark red, light red (striped).
Jonathan	Dark red, light red (striped).	Yellow Newtown	Yellow, green, red (striped), russet.
King	Yellow, dark red, light red (striped), russet.		

Not all the color units present may appear distinct and pure in any single specimen, but even under such circumstances they are generally *indicated*, and by the observation of a series of specimens these units of color will be found pure.

As suggested by Hedrick and Wellington, red does consist of at least two and probably more unit characters. From the foregoing list it will be noted, moreover, that some varieties, such as Yellow Newtown and Baldwin, carry factors for several colors and for russeting. Yellow is sometimes difficult to detect because of the green present. Two other points are worthy of attention. First, that generally the color factor for light red carries with it the factor for striping, whereas, the factor for dark red is associated with solid

color. This association, however, is not always found. Second, the deep red is markedly dependent on exposure to the sun for its best development. For example, the red in Shiawassee, McIntosh and Jonathan, is composed of at least two reds, the one light and carrying with it the factor for striping, the other dark and associated with the factor for soild color. Now if these apples are grown under poor light conditions, they are almost without exception light red and striped, while in full sunlight the deep red factor further manifests itself and the fruit becomes self-colored dark red, though on close inspection the stripes are evident beneath the solid color. This is not a case of segregation; both characters are present, the one being simply overlaid by the other. A third bronzy red appears in certain varieties, such as Monmouth and very noticeably in Baldwin.

It has been frequently suggested that should we be able to find such banded fruits on the tree, mark the spur and in later years find similar fruits produced on the same spurs, then there could be no doubt as to the existence of bud variation. As pointed out above, it is quite as possible to have flower bud variation as "shoot" variation. Among pears, however, we have abundant evidence that the striping does extend to the branch which bears the fruit. Three years ago I discovered a Bartlett pear tree which was bearing on one limb peculiarly striped fruits which in every other way were entirely normal. As the pears hung on the trees they resembled miniature watermelons. The body color was dark green with numerous light yellow stripes of varying width from calyx to stem. The owner of the orchard at once concluded that

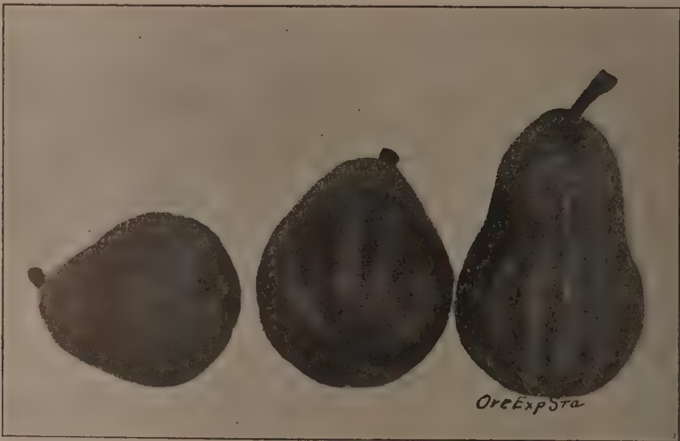

Fig. 22. Bartlett pears showing the light yellow bands extending from stem to calyx.

the stripes were the result of cross pollination. The only other variety near was the Winter Nelis. There were about 50 of these fruits, all close together. This fact indicated at once that here evidently was a bud sport. Closer inspection revealed the fact that this was certainly the case, for the striped fruits were all borne on one limb and not only were the fruits themselves striped but the bark also showed long parallel bands of yellow and brown. This branch was at least six years old at the time of discovery and could readily be traced to its origin from a much larger limb, which, like the remainder of the tree, was bearing normal, unstriped fruit. Buds were taken from the striped wood and inserted into seedling trees on the Station grounds and have since made considerable growth. Two facts are of interest in these young trees: First, those trees resulting from the yellow buds have light yellow bark with a few

dark stripes, whereas, those from the dark buds have a very much darker bark but still show a few of the pale yellow bands. Second, the young leaves on the trees having lighter bark show distinct irregular pale yellow blotches; those on the dark barked trees fewer but similar light green blotches. In both cases these blotches disappear as the leaf matures. The light trees are also more "limby" and have more short spurs along the main axis than do normal Bartletts; but the dark form resembles the latter much more closely, the only difference being the occasional light stripe in the bark and the color of the young leaves.

In the fall of 1910 a number of fruits of Winter Nelis pears showing a peculiar banding of plain yellow in the normal more or less russeted background, were referred to me. This marking was very striking in the green fruits, but became less marked at maturity, when the entire fruit was more or less yellow, but even at that time these bands were evident because of their lack of russeting. During the past summer the tree from which these specimens came was located, and a condition exactly similar to that explained for the Bartlett above was observed. The striped wood could be traced back for five years; or in other words, to the main limb from which the variation had sprung. Buds have been inserted into seedling trees, but as yet have made no growth.

An extremely brief review of horticultural literature gives us many records of striped strains of well recognized varieties. Many excellent figures are given, some of these showing the wood as striped, others plain. A number of the appended descriptions also mention the striping of the wood as a varietal character. The mention of a few of these specific cases may not come amiss. Decaisne (6) gives two excellent figures, the one Amoselle Panachée, with plain brown bark though he mentions the fact that pale bands are sometimes visible, the other Bergamote Panachée, with the bark showing longitudinal stripes of green, brown and yellow. He mentions a third variety, Verte-Longue Panachée (Culotte de Suisse) as a variety of Mouille-Bouche, having the stem and frequently the leaves variegated. Baltet (7) mentions this latter variety and adds, "Buerre d'Amanlis, William, Duchess, Louise-Bonne, Buerre Diel, Buerre d'Hardenpont and Belle Angevine have also their striped sub-varieties." Carrière (8) mentions in addition to the foregoing, the following: Amanlis panachée, Saint-Germain panachée and Double fleur panachée. Kenrick (9) adds Crassane panachée—leaves variegated; an ornamental variety—Doyenne panachée and Bon Chretien panachée. The following list By Dr. Stoll (10) is interesting. I give it complete though it duplicates some of the preceding: "Alexander Lambré, Blumenbachs Butterbirne, Crasanne, Alexandrine Douillard, Graue Herbstbutterbirne, Grüne Magdalene, Gute Luise von Avranches, Hardenponts Butterbirne, Herzogin von Angoulême, Junker Hans, Lange grüne Herbstbirne (Schweizerhose), Leckerbissen von Angers, Lucie Grievu, Marie Lessueur, Regentin, Runde Mundnetzbirne, Russelet von Reims, St. Germain, Spätter Hardenponts, Triumph von Vienne, Vereins-Dechantsbirne, Weisse Herbstbutterbirne, Wildling von Chaumotel und Williams' Butterbirne." A seedling of Marie Lessueur possessed one yellow striped cotyledon. Instances might be multiplied, but the number cited will serve to show the frequency with which this variation has occurred.

It is of special interest to note, too, that the variation extends to the branch, thus making vegetative propagation possible; whereas, in the apple I have never seen the striped effect extended to the branch. Yet such varieties as the Gravenstein, Collamer, and possibly Gano, in which a different color or color pattern is exhibited by the entire fruit, are well known.

Further instances of color variations in fruits may well be cited. Among grapes there is frequent mention of the variety Chasselas and its two varieties, C. Panachée, in which parts of a berry or entire berries are russeted, and C. suisse, in which bands of white and yellow appear in the berries, or in which the berries may be entirely white. Carrière (8) further mentions the plum, Coe violette, which is a variation of the plum, Coe "blanche," and the currant, "Gloire des Sablons," which is a variation of the ordinary currant. Du Monceau (10) in writing on Citrus (C. Bigarradia violacea), figures the same, and quotes

Le Birryais to the effect that on the same tree voilet striped and non-striped fruits appear, and that leaves and shoots occur with and without purple coloring. "The young fruits are striped violet and green, but at maturity are entirely deep yellow. In propagating this tree it is necessary to select grafts from the branches of which the growths are violet. In cutting them, it is also necessary to preserve more violet buds than green ones, for if one of the two kinds, especially the green, dominates, it appropriates the entire tree, which becomes entirely common bitter orange, or violet bitter orange." At this point it is interesting to refer again to the striped Bartlett trees mentioned above, in which buds of different color on the same twig produced trees quite different in character, the darker form reverting more nearly to the parent stock.

A few instances of somatic segregation of characters other than color as exhibited by the fruits themselves are given herewith. Cox (12) mentions the sweet and sour apple, which "derives its name from the peculiar property of possessing these different qualities in the same fruit; the surface is often uneven, the prominences having one taste and the hollows another." Professor V. R. Gardner recently called my attention to the Le Conte pear—a hybrid between Pyrus communis and Pyrus sinensis, in which the character for persistent and deciduous calyx seems to be unstable. Some fruits on the same branch possess heavy fleshy calyx lobes, others a persistent dry calyx, others absolutely none. All degrees intermediate such as two fleshy and two lacking, one fleshy and four dry, two dry and three lacking, etc., exist. He also tells me of an almond tree which bears both sweet and bitter fruits, scattered throughout the tree. The writer has often noted many wild-crabs which abound along the streams and fence rows. They are hybrids of Malus rivularis x M. malus. The fruits on the same tree will show all degrees of persistence of the calyx lobes—from complete persistence to entire absence. As is known the calyx of Malus rivularis is generally deciduous, whereas, in M. malus it is generally persistent. Some of these natural hybrids, however, are very uniform in all characters, with little or no tendency to variation in the same individual.

Several times I have found on the markets, or have had referred to me, specimens of oranges which manifested pecularities in the texture and coloration of the skin. Bands or segments of the skin of varying width, from stem to blossom end, were not only of a much finer texture but much lighter yellow in color and generally sunken somewhat below the general surface level, though sometimes more elevated; rarely on the same level.

Risso and Potieau (13) mention in detail the peculiar formation of the skin as found in the Bigaradier bizarrerie—a bitter orange having longitudinal segments of the skin comparatively smooth, and, alternating with these, segments which are exceedingly rough and knobby and of a different color. The form likewise varies, resembling both the orange and lemon. This example seems to be an extreme development of the character noted above for the common sweet orange.

Horticultural and botanical literature abounds with examples of this kind, but the few above adduced will afford a general idea of the range of characters which may exhibit themselves. The point of special interest lies in the fact that the combination of characters which in general is uniform throughout an individual, at times becomes unstable. Some of the characters split apart and exhibit themselves separately and distinctly. As De Vries (14) has already pointed out, this separation may well be termed a kind of vegetative mutation or a vegetative segregation. Certain of the Mendelian factors themselves, or even different combinations of these factors, which normally may maintain their independence, during the life of the plant, may occasionally separate and each exhibit itself independent of the other.

Thus it is quite possible to conceive of a splitting apart of characters during the processess of cell division within the somatic tissue itself. For example, if in the red of Esopus (Spitzenberg) the factors of red and yellow be present, i. e., if the red is heterozygous, it may be supposed that in mitosis these factors actually become distinct and separate the one from the other,

and to the one daughter cell one factor is transmitted pure and to the other, the remaining factor, also pure. If this were true and both daughter cells survived and multiplied, we would expect to find pure areas of greater or less extent of either kind in close proximity, or if but one of them survived, an area of variable extent of a color corresponding to the color factor present and surrounded by the normal blended color.

Both of these conditions are clearly evident in the two examples of Esopus (Spitzenberg) shown. In the one, there is a band of deep red lying next to a band of pure yellow, and both of these are surrounded by the normal yellowish red. In this example both daughter cells have survived and reproduced themselves pure,the one possessing the color factor for red, the other for yellow only. The color of the remainder of the fruit is still in a heterozygous state, possessing both red and yellow color factors. In the other illustration, it will be noticed that there is a broad pure yellow band surrounded by the normal (heterozygous) red. This is by far the most frequently occurring condition in Esopus (Spitzenberg). Only the cell possessing the factor for pure yellow has survived and multiplied, with the result that there is no pure red band, the normal color enclosing the yellow band on all sides. The factor for striping appears to be separate from both the red and the yellow in this variety.

The illustration of the Ben Davis is also worthy of consideration. One-half of this fruit is of the normal striped red, which is homozygous (or shall we say heterozygous light and dark red), the light red seeming to be associated with the factor for striping and the dark red for solid color as noted above. The other half is of the solid deep red color.

In the case of the Yellow Newtown, it will be noted that the recessive factors for both red color and striping have been allowed to appear by the suppression or elimination of the dominant factors for solid yellow color.

Further examples of this striping might readily be cited and commented upon. Suffice it to say, however, that the amount of the fruit affected may vary from a very narrow segment to the entire fruit, as in the case of the Red Gravenstein. It is also worthy of note that the recording of the color of the bands which appear on our several cultivated varieties, may be of considerable importance to apple breeders. For if one is able to determine the color composition of an apple beforehand, he can more readily select the varieties desired to produce offspring of a definite color than if he knows nothing of such a composition.

The same reasoning as suggested above for color variations can be applied equally well and justly to the morphological differences pointed out in the several cases cited. De Vries (14) lists many more. Some individuals (or may we say varieties). seem to possess as one of their definite characteristics the very loose combination or blending of certain characters. So loose is this combination, in fact, that they continually tend to split apart, segregate or become pure. Thus, as shown above, the "Bigarade violette" tends to revert to the normal form unless those buds and branches showing considerable of the violet are continually selected, or the Bartlett pear which, in tree characters, at least, tends to revert to the type from which it sprung, unless buds showing the greatest variation are chosen. What the fruit characters from these two types may indicate later cannot now be said. These two forms when entirely segregated may indicate more nearly the types from which the Bartlett has sprung than that variety itself. But the special point to be again emphasized is this. that when any variety character is made up of a combination of other characters, it is entirely possible for these characters to separate and manifest themselves as characters apparently new to the individual. Generally such characters can in no sense be regarded as new but only as having already existed in combination with others, and their apparent newness or addition is nothing more nor less than a purifying, eliminating or segregating process by which other factors which masked them have been suppressed or removed. Such segregation generally has been called bud variation.

Summary.

1. Color in the pome fruits is not influenced directly in the immediate cross.

2. New characters cannot be added by the pollen, outside the seed itself, in the immediate cross.

3. The manifestation of color is dependent on many environmental factors.

4. Color as usually found is composed of a number of unit characters.

5. Somatic segregation may occur and by this means the several factors or color manifest themselves more or less independently. The several colors may appear as bands more or less parallel, or a band of but one color surrounded by the normal color.

6. Similar segregation may extend to any group of unit characters of which the plant is composed.

7. Segregation may extend to either fruit or leaf buds, if the latter such variations may be propagated asexually.

8. Red in apples may consist of either a single or a complex of unit characters; at least, three reds are recognizable.

9. Somatic segregation may be of service to plant breeders as indicating the unit characters of a plant that are likely to exhibit themselves when propagated sexually.

10. Segregation generally extends to the flower bud only in apples, while in pears the shoot is frequently affected.

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Report

OF

Department of Entomology

The Insectary.

REPORT OF THE DEPARTMENT OF ENTOMOLOGY.

Introduction.

The appropriation provided by the Crop Pest and Horticultural law became available in May, 1911. July 1, 1911, the work of the Department of Entomology under this law was organized under the immediate supervision of Mr. H. F. Wilson with Mr. A. L. Lovett as assistant. Mr. Wilson is directly responsible for all orchard insect investigations, while Mr. Lovett has been assigned the study of the insect pests of small fruits and vegetables. Practically all of the work covered by this report should, therefore, be credited to Mr. Wilson and Mr. Lovett.

At the time of organization, this department selected for study some of the most serious insect pests of economic importance in the state of Oregon.

The Shot Hole Borer (*Xyleborus dispar* Fab.), the Brown Apple Aphis (*Aphis sorbi* Kalt.), and the Strawberry Root Weevil (*Otiorhynchus ovatus* Linn.) were selected for primary investigations. In addition to these, as time and circumstances would permit, a number of less important insects have been studied. Such information as we have been able to secure on the various pests investigated will be found included in this report. The work of these major problems will be continued, and, in addition, it is the intention of the department to take up the following insects one by one, and to work out the life histories and methods of control:

1. Woolly Apple Aphis *(Eriosoma lanigera)*.
2. Fruit Tree Leaf Beetle *(Syneta albida)*.
3. Bud Moth *(Tmetocera ocellana)*.
4. Cherry Fruit Fly Maggot *(Rhagoletis cingulata)*.
5. Strawberry Root Miner *(Aristotellia sp.)*.
6. Garden Slug and Root Maggots.
7. Currant Fruit Fly *(Epochra canadensis)*.
8. The Cucumber Beetles *(Diabrotica soror)* and *(Diabrotica trivittata)*.
9. Onion Thrips *(Thrips tabaci.)*
10. Vetch and Pea Aphis *(Macrosiphum pisi)*.
11. Clover and Alfalfa Insects.

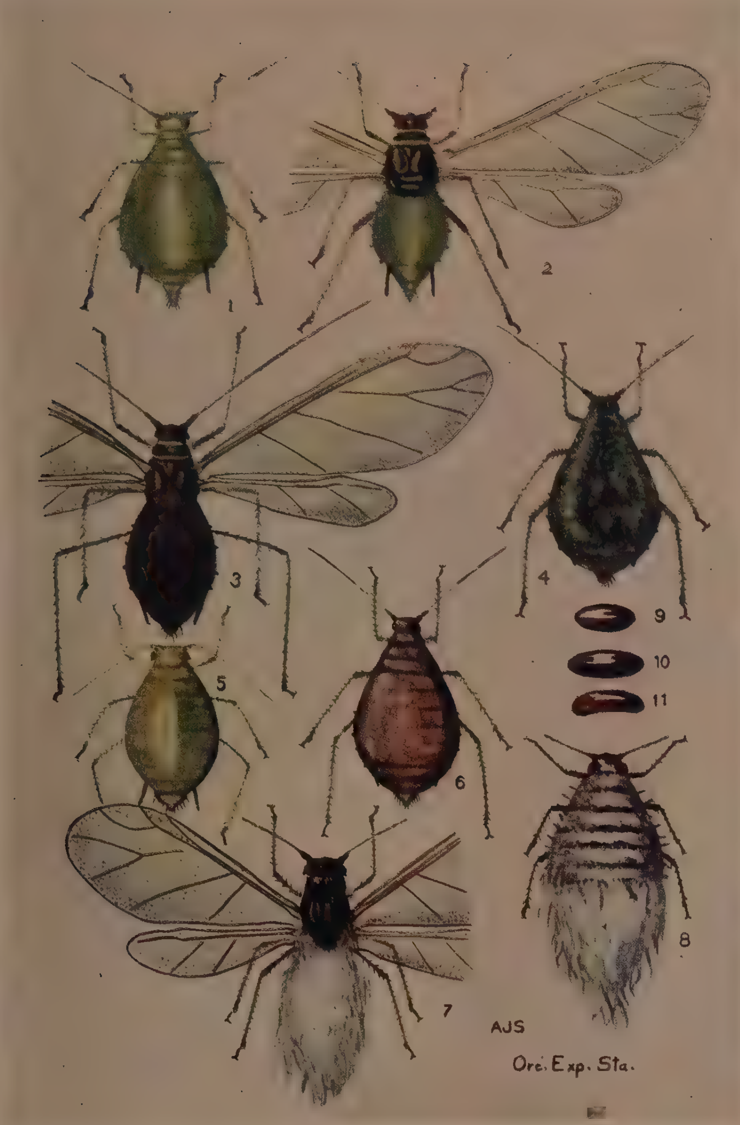
Up to this time, we have given little attention to field crop insects, but because of the frequent calls for assistance from farmers who are trying to raise vetch, clover, alfalfa, field peas, etc., for seed and hay, we feel warranted in starting preliminary studies for control of the more serious pests of these important crops.

In connection with the laboratory work, the investigations have been carried on in the field, and during the past two years members of the department have visited nearly every section of the state. In this way, considerable help has been given to the farmers and orchardists of every section of the State; and it is the intention of the department to continue this field work as much as time and funds will permit. Special trips were made to investigate reported outbreaks of injurious insects.

The efficiency of the department has been materially increased by the funds secured from the Crop Pest appropriation. New men have been added to the staff and we have been enabled to make numerous visits to the farmers at their homes for the purpose of conference and advice upon the insect problems with which they have to deal.

The departments of entomology and plant pathology are also conducting a series of co-operative experiments, in an effort to determine whether a combination spray composed of Zinc Arsenite or Arsenate of Lead, neutral or acid, and lime-sulphur, possess the same insecticidal and fungicidal values as these substances possess when used separately. This work was commenced in the spring of 1912 and will extend over a period of three years.

A. B. CORDLEY.



The Green Apple Aphis, figures 1 and 2. The Brown Apple Aphis, figures 3, 4, 5 and 6. The Woolly Apple Aphis, figures 7 and 8. Egg of the Brown Apple Aphis, figure 9. Egg of the Green Apple Aphis, figure 10. Egg of Woolly Apple Aphis, figure 11.

PLANT LICE ATTACKING ORCHARD AND BUSH FRUITS IN OREGON.

By H. F. WILSON.

The present work is issued as a popular treatise of all the plant lice which are known to be working on orchard and bush fruits in Oregon. The experimental work is based upon conditions as we have found them in this State.

More attention has been paid to the Brown Apple Aphis, for the reason that no other one species of aphis causes anything like the amount of damage caused by this insect in all sections of the State, north, south, east and west. In some few sections the Woolly Apple Aphis is quite bad, but where thorough spraying is carried on for San Jose Scale and other insects, this species is of minor importance. On young nursery stock the Green Apple Aphis frequently becomes bad, and the trees must be sprayed or they sometimes die as a result of the injury.

Definition of Terms Applied to Plant Lice in Description of the Various Stages.

The Egg is the stage in which most of the plant lice spend the winter, attached to twigs, under bud scales, pieces of bark or on the open surface of the young shoots of such shrubs or trees as serve for the overwinter host plant.

The Stem-Mother.—So-called because in the spring she hatches from the egg and is the mother aphid of all the generations produced throughout spring, summer and fall. She is not fertilized and produces her young alive. For this reason the stem-mothers are said to be viviparous producers and all of the many succeeding generations produced through the summer are viviparous females.

The Spring Migrant.—With the second or third generation in the spring, winged forms appear which leave the original home and migrate to new plants where new colonies of young are started. This migration usually occurs in May and June and these winged forms are known as Spring Migrants. During the summer months most of the lice are apterous, i. e., wingless, and are called apterous viviparous females.

The Fall Migrant.—In the late fall the winged forms again appear and scatter to new plants, where they give birth to the larvae which develop into egg-laying females and usually males; sometimes the males are migratory and are produced on the same plant with the viviparous females. (This is true of the Hop Aphis and perhaps of the Brown Aphis of the apple.)

The Males may be either winged or without wings, and it is claimed that in some species both forms exist.

Honey Dew is an excretion thrown off through the anus of each individual, as a waste product. It is generally believed that this is a secretion issued through the honey tubes or nectaries. The fluid which is thrown off from the latter is never very abundant and perhaps acts as a repellant against natural enemies.

Migratory forms of each species appear at certain times of the year and spread to new host plants. This habit is probably nesessary for the continuation of the species, for should all be produced on one plant the numerous aphis enemies would have little trouble in destroying them. Under normal conditions during the summer months the numbers become so reduced as to exist only in isolated colonies; from these colonies large numbers of winged forms develop, and by locating anew, avoid their enemies for the time being.

All the insects of this class are placed together under the group name *Aphididae*. Here are included all those insects which, besides having sucking mouth-parts in the form of a beak, have one pair of antennae with segments varying in number from three to six; with two pair of wings in some one or more stages and with two nectaries or honey tubes which vary greatly in development. These are said to be always found on the fifth segment of the abdomen. The entire body is divided into three main parts, the head, thorax

and abdomen. The head is furnished with the antennae, two compound eyes, three simple eyes or ocelli, and the suctorial beak. The thorax bears the two pairs of wings and the three pairs of legs. The wings bear a number of veins which vary in size and placement with different species. The abdomen is composed of nine segments and bears the nectaries and cauda or tail.

THE ROSY APPLE APHIS.

(The Black Apple Aphis.)
(The Brown Apple Aphis.)
(The Purple Apple Aphis.)
(*Aphis sorbi* Kalt.)

Of all the plant lice attacking fruit trees in Oregon at the present time, the Rosy Apple Aphis is by far the most serious pest.

A native of Europe, this insect, probably imported into North America on nursery stock, has spread to most of the apple growing sections of the United States.

No orchard section of Oregon appears to be free from its ravages, although some sections seem to suffer more than others.

The various forms which this species assumes during a season has occasioned no less than four common names which are used in different sections of the Northwest. Each of the stages are so different in color and general appearance that they might each be designated as a different species by the fruit grower.

In the early spring we have the greenish blue stem-mothers covered with white powder; following these we have the pink forms which begin to occur about June 1. These are the pupae and later change to the brownish or black so-called spring migrants. In the late fall we have the whitish egg-laying or oviparous females. These continue on the trees until killed by the late frosts, usually in the later part of November.

This pest has the disagreeable habit of attacking only the leaves surrounding a fruit cluster, except in years when the crop is light, when they may be found almost anywhere on the leaves.

Since under normal conditions the fruit itself is not attacked, the layman fails to associate the aphis with the small, gnarled, gall-apples which appear as a result of their work in the fall at picking season.

We do not just know why the apples become deformed, but apparently the juices which would naturally go to produce growth in the fruit are drawn into the leaves and absorbed by the aphids. In extreme cases, when the leaves are caused to become curled and more or less functionless, the juices fail to extend themselves, except in a limited way; hence, even after the lice have left for the summer, the fruit fails to receive a sufficient food supply. In an orchard where the aphis has been bad during the early growing season, many gall-apples will be found hanging on the trees long after the leaves have fallen. These gall-apples vary in size according to the amount of injury from as large as hazelnuts to nearly full grown apples. The injury to the fruit, no matter how little, is so definite that it is apparent on fully matured apples which have belonged to a cluster where a half-dozen aphis have worked on a single leaf. The injury will be on that side of the apple next to the infested leaf. This injury, when slight, is found on the crown of the calyx and will appear as small depressions barely discernible to one familiar with any certain variety of fruit. (For effect of injury, see plate II.)

This louse seldom attacks the young growing shoots, as in the case of the Green Apple Aphis, but we have noticed that when all the leaves of a certain terminal shoot are covered, the lice will gradually work down the shoot until many hundreds of individuals will be found working along the new growth.

The entire life history of this insect has not been worked out, although for two seasons an effort has been made to do so. We are working on this pest in the interest of the fruit grower, however, and probably would not be benefited by any additional information.

Plate II.

The Rosy Apple Aphis *(Aphis sorbi)*. 1. Aphids on leaves of fruit spur. 2. Six fruit clusters from the same limb, the center one uninfested. 3. Just after petals have fallen, too late to spray. 4. Photograph taken in January showing aphised apples still hanging on trees. (Original.)

Life History.—This louse spends the winter in the egg stage, and the little dark green stem-mothers hatch out just as the buds begin to open in the spring. In 1911 this was about the first of March. In 1912 the first young stem-mothers were observed February 22. They cluster on the green tissue of the opening buds and gradually work down among the leaves as they open out.

At first they are hard to find, but as the buds open and they increase in size they can be very easily located. The number present in a single bud may vary from one to twenty-six, with an average of less than ten.

By April 15 of an average season the colonies are well established on the under side of the leaves, and the leaves have become so curled as to make spraying unprofitable.

About June 1 a pinkish or salmon-colored form appears. These are all pupae and produce the brown migratory females which soon after maturing disappear from the apple and probably locate on some one or more unknown plants where the summer generations are produced. Before the final molt, in which the pupae change to the adult form, many pupae migrate from the leaves, and crawling down to the larger limbs and the trunk, collect under the loose bark. They remain there for a few days, molt, and as soon as their wings have hardened, leave. There seems to be no apparent reason for this, unless it is to get away from the various enemies which attack them on the leaves. Most of the migrants have disappeared by July 5 and do not appear on the apple again until late September. At that time scattered individuals of the fall migrant form begin to appear on the under side of the leaves, and more and more appear during the month of October, so that by November 1 they are quite abundant.

They continue on the leaves apparently feeding, but not producing young, until late October, when numerous little light-colored objects begin to appear in the vicinity of the migratory forms. These develop later into the whitish egg-laying females, and November 1, 1911, a few mature forms were found depositing eggs about the buds on young shoots. No males could be found at that time, although a few must have been present. Specimens collected November 8 proved to be migratory females, males and egg-laying females. Evidence is not yet conclusive, but the sudden appearance of the males without the previous appearance of pupae would indicate that the males are migratory and are produced on the summer host plant.

The eggs of this species are not nearly as abundant as those of the Green Apple Aphis, are more scattered, and are usually deposited on the older growth.

Description of the Various Stages.

The Stem-mother.—(Plate I, fig. 4.)—When mature, this form is broadly oval in form and of a general dark green color; head black; abdomen, from base of nectaries to tip, pinkish; antennae and legs, dusky. The entire body is covered with whitish bloom or powder. The antennae reach to the middle of the body and the nectaries are about one-fifth of the length of the abdomen. On each side of the thorax is found a single dentate tubercle, and five or six more are found on each side of the abdomen. Just above the base of the cauda are located two pairs of dentate tubercles, one pair being slightly higher on the abdomen than the other. Cauda short and blunt.

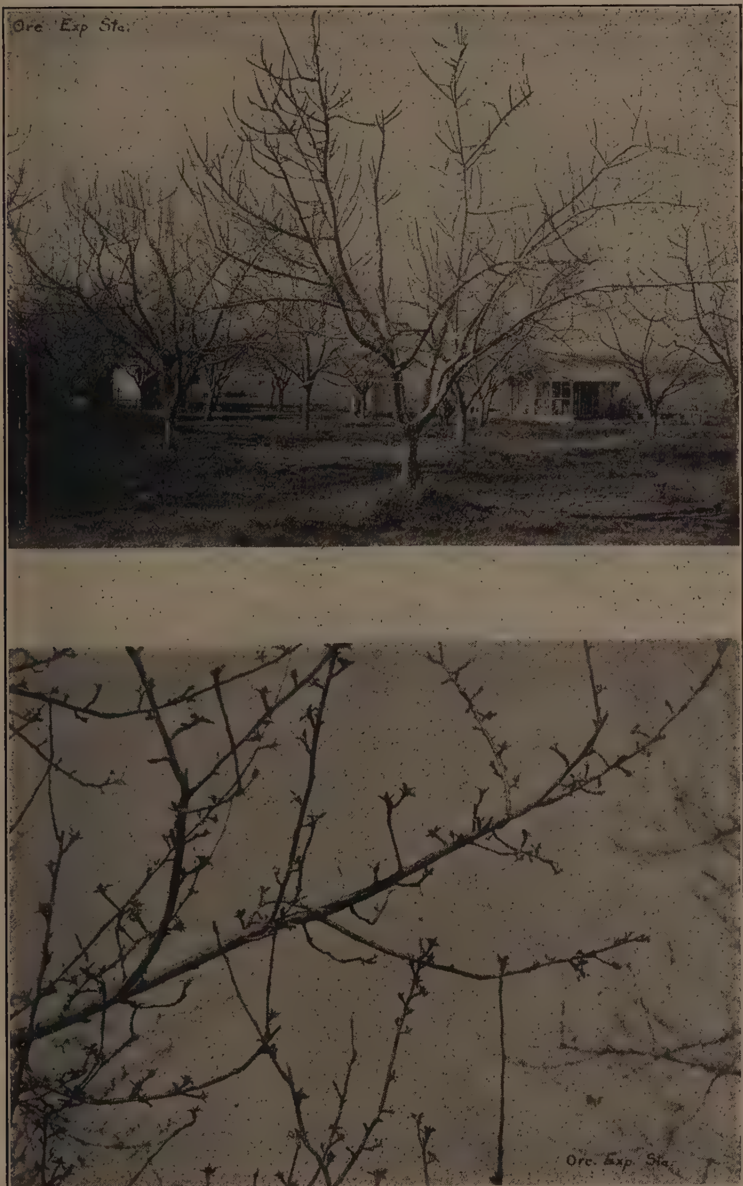
The Spring Migrant.—(Plate I, fig. 3.)—General color of head and thorax black, abdomen brown with black markings and a black dorsal square-shaped spot. Antennae about as long as the body and black to brown. Nectaries dusky at base to black at the tip. Along each side of the abdomen is a series of dentate tubercles and between the base of the cauda and nectaries are found two pairs, one pair slightly above the other.

The Fall Migrant.—General color of head and thorax black. Abdomen with brown markings and a dorsal square-shaped spot. Antennae about as long as the body and black to brown. Nectaries dusky at base to black at the tip. On the distal part of the abdomen, back of the nectaries and at the base of the cauda, are two pairs of dentate tubercles; one pair being slightly above the other.

Egg-laying Females.—(Plate I, fig. 5.)—This form is yellowish green with antennae and legs dusky. A pinkish spot surrounds the base of each nectary, nearly touching at the inner edges; nectaries dusky at the tip; antennae shorter than the body and spur of sixth segment longer than the third and fourth segments.

The Males greatly resemble the winged females except that they are smaller in size. General color dark brown. Antennae, head, and thorax nearly black; third, fourth and fifth segments with

Plate III



The Rosy Apple Aphis *(Aphis sorbi)*. Photographs showing condition of orchard at time of spraying—1912. An ideal time to destroy aphis and scale.

numerous raised circular sensoria. Distal half of tibiae, tips of femura and tarsi black; nectaries, black. Dorsum of abdomen with five to six transverse brown bands, abdomen light brown, cauda short and wart-like.

The Eggs.—(Plate I, fig. 9.)—The eggs of this species are much smaller than those of the Green Apple Aphis and are more pointed at the ends. When first deposited they are light green in color but soon change to a shining black. They are deposited for the most part about and under the buds, occasionally one may be deposited on the open bark.

Remedies.

During the spring of 1911 a series of experiments were carried on for the control of the Brown Apple Aphis in which lime-sulphur, "Black Leaf-40," and lime-sulphur and "Black Leaf-40" in combination, were used. All three of these sprays were applied at two different dates in order to find the most suitable time for the best results.

The first application was made March 30 and at that time the leaf buds were just opening. (See Plate III.)

The second set of sprays were made April 25 at the time of the first scab spray. The fruit buds were just showing pink, the leaves were nearly all out and many were already curled by the plant lice.

Several rows were used for each experiment and the results obtained were quite conclusive.

The "Black Leaf-40" and combined spray of lime-sulphur and "Black Leaf-40" were equally efficient. The lime-sulphur alone failed to have any effect on the aphids. The lime-sulphur was used winter strength (1-10).

In the case of this insect, spray applied after the leaves have curled is almost worthless, owing to the fact that the leaves are so tightly curled that the spray cannot be made to penetrate to where the lice are feeding.

Spray thoroughly applied at the time when the buds are just opening will prevent 95 to 100% of aphis infestation.

The lime-sulphur should be used winter strength and the "Black Leaf-40" added at the rate of one part to 900 parts of the diluted lime-sulphur.

THE GREEN APPLE APHIS.

(*Aphis pomi* DeGeer)

This species is easily distinguished from the other plant lice which infest apple trees in Oregon, and as it spends its entire life cycle upon apple, pear or hawthorn, it should not be confounded with other green aphids found on various cultivated and wild plants.

It does not commonly occur on pear trees in this state but is often quite abundant upon the other two hosts.

Life History.—The winter is passed in the egg stage upon the water sprouts and young twigs, where they are deposited in the fall by the egg-laying females. During favorable seasons the eggs are so thick as to make the twigs appear black.

Observations made by ourselves and others show that most of these eggs fail to hatch. The few which do hatch, however, develop quite rapidly and produce abundant colonies by the middle of the summer.

Gillette and Taylor (1) state that in Colorado the eggs begin to hatch a little before the buds show green and continue to hatch through a period of from two to three weeks.

In the Willamette Valley practically all of the eggs are hatched by the time the buds burst. This is also true of the Brown Apple Aphis, and if one will observe the buds in the spring, just as the bud cases are breaking, little dark green aphids will be found crowding in to reach the out-coming leaf tissue. As the buds expand and the leaves appear the lice work down to the more protected places among the folded leaves.

These spring forms are known as stem-mothers because each year they are the first of a series of generations or broods which appear during the summer. They are also the only ones which hatch from the eggs as all the later forms are born alive.

(1) Bull. 133, Colorado Exp. Sta.

During the second generation after the stem-mothers, winged forms appear which are commonly known as the spring migrants. These forms leave the parent colony and migrate to new places where they start producing alive, young lice that form the summer colonies. Migratory forms appear in all of the succeeding generations until the egg-laying females and males are produced in the fall; both of the latter are wingless, and after copulating, the females deposit eggs until killed by frost. The eggs are green when first deposited but soon turn to a shining black.

Description of the Various Stages.

The Stem-mothers when first hatched, appear like little dark green specks. As they develop and become larger the color becomes a little lighter green. When full grown they measure .06 of an inch in length.

The Migratory Females (Plate I, fig. 2) are without wings when first born and when nearly mature assume wing pads. They are then known as pupae. When fully developed the pupae all at once shed their skins, and a new form comes forth with large transparent wings. At first these are folded along the side of the body and do not spread out for several hours. This form is in general, light green in color with black antennae, head, thorax and nectaries. They measure about .08 of an inch in length.

The Wingless Summer Forms (Plate I, fig. 1) resemble to a great extent the stem-mothers except that they are longer and that the body color is of a lighter green.

The Egg-laying Females are of a lemon yellow in color and are smaller than the lice of any other generation, unless it be the stem-mothers. They can be quite easily found in the fall out on the tips of the young shoots where they are depositing eggs.

We have observed that quite a few eggs are also deposited on the leaves. The young lice which hatch from these probably never live to reach the trees in the spring.

The Males are pinkish brown in color and wingless. They resemble the immature females so much that only by causing the penis to protrude can one locate this form to a certainty.

Many observations failed to show males on the twigs, while they were abundant on the leaves. Copulation probably takes place on the leaves before the females go to the twigs to deposit eggs.

Remedies.

1. Spray in the spring just as the buds are opening with lime-sulphur plus "Black Leaf-40" or with "Black Leaf-40" alone.
2. Spray trees in foliage with "Black Leaf-40," Kerosene Emulsion or Whale Oil Soap.

THE WOOLLY APPLE APHIS.

(Eriosoma lanigera Haus.)

This aphis (Plate I, Figs. 7, 8 and 11) probably a native of North America was first reported from the British Isles where it was known as American Blight before the real nature of the pest became known.

It seems to have been known in America as far back as 1790, and one English writer mentions the remedies used at that time.

The complete life history of this insect has never been worked out, although much has been written of it, and considerable work has been done with remedies.

Several entomologists have tried to work out the detailed habits but without complete success. Gillette and Taylor (2) have published the most complete work on this insect, although they were unable at that time to tell what became of the winged forms which migrated from the apple in the fall and were known to produce the oviparous females and the males. In a letter written several years after the above paper was published, Prof. Gillette suggested the possibility of the connection between the Woolly Aphis of the apple and the similar dark red woolly aphis which is found on the leaves of elm. During the fall of 1911 numerous winged individuals were transferred from apple to elm trees where males, oviparous females and eggs later appeared. The following spring the writer watched for the stem-mothers to appear and was much gratified to find, in due time, the lice and curling leaves. When the galls became fully developed, however, they were found to be quite different from those ordinarily made by *Eriosoma americana* and the lice themselves appeared different. In addition to this no specimens of *E. americana* or galls of that species could be found in the vicinity of Corvallis during the

(2) Bull. 133, Colorado Exp. Sta., 1908.

season of 1912. Specimens taken from the galls present were then transferred to apple seedlings and in a short time well established colonies of a woolly aphis could be found where the transferred specimens had been enclosed by paper sacks.

In the meantime Miss Edith M. Patch of the Maine Agricultural Experiment Station, has published in Science (3) a preliminary note entitled "Elm Leaf Curl and Woolly Aphid of the Apple." She has made observations somewhat similar to those of the writer and it is very probable that the two will be established under one name in the next year or two.

In addition to the migratory forms on the apple there also exists a hibernating form which can be found on the apple during the winter months.

In Oregon there are numerous regions where no elms are grown and yet the woolly aphis of the apple is quite plentiful on apple trees. This would indicate that those forms which remain on the trees may continue indefinitely without building up the stock from the alternating forms on the elm.

General Appearance.

At first glance a number of these lice feeding together in an old scar or wound, or on a young twig, appear like a mass of moving cotton. Upon closer inspection this mass will be found to contain numerous individuals covered with a white waxy substance which takes the shape of threads, and which serves more or less as a protection to the louse. This waxy substance can easily be rubbed off, thus exposing to view the purplish brown body. In each group, in the fall of the year, winged individuals may be noticed, the wings appearing dusky and projecting straight out from the cottony masses.

Remedies.

These should begin with a thorough inspection of the nursery stock when it is received; any clods or dirt hanging to the roots should be washed off, and if any lice are found either on the roots or top, the stock should be thoroughly sprayed with "Black Leaf-40" (1-800), or dipped for six seconds into water at 125° F.

On parts attacked above ground, any spray which will kill other plant lice will also destroy this species. The spray must be applied with force enough to penetrate or wash off the white waxy secretion.

On parts attacked below ground the sprays used above ground will be efficient, but before they can be applied the infested roots must be exposed so that the spray can be made to reach the lice.

Continued interruptions of observations and incomplete data upon experimental work with this species, will not permit us to give any additional information concerning it at this time. A complete bulletin will probably be issued in the future.

THE EUROPEAN GRAIN APHIS.

(*Aphis avenae* Fab.)

The European Grain Aphis is so-called because it is more common on grain and grasses. The apple is an alternate host where the insect passes the winter in the egg stage. In the eastern part of the United States this insect is a common pest of the apple and is occasionally found on pear and hawthorne. In Oregon we have found a very few scattered colonies on apple while on grains and grasses they are quite plentiful.

During our studies of this species we have observed specimens on orchard grasses very early in the spring so that it is quite likely that they live over on the grasses without producing the sexes and eggs on the apple.

When present on the apple this species is said to curl the leaves in a manner similar to the Green Apple Aphis.

In general appearance this aphis resembles the Green Apple Aphis, but a series of transverse stripes of dark green across the abdomen and the light-colored honey tubes will serve to separate the two species.

(3) Vol. 36, N. S., pp. 30-31.

Remedies.

Same as for Green Apple Aphis.

THE CLOVER APHIS.

(*Aphis bakeri* Cowen)

This aphis is commonly known as the Clover Aphis for the reason that it is found on clover during the summer months and the name was applied before it was known that apples, pears, crab-apples and hawthorns were alternate hosts. We have found the stem-mothers quite abundant upon the hawthorn *(Crataegus douglasii)* as early as the first of March, and by June 1 the later generations can be found in colonies on the leaves.

About June 1 the winged forms appear and migrate to both the red and white clover, where they remain until fall. Then winged forms appear on the clover, which migrate back to the overwintering hosts.

Occasionally a few stem-mothers can be found on apple, pear and quince, but not in numbers great enough to cause any appreciable damage.

In appearance the stem-mothers of this species are usually pink or red with markings of mottled green.

The later generations of the fruit tree hosts are yellowish green with an orange colored spot surrounding the base of each honey tube. On clover the wingless forms are quite variable in color from yellowish green to a deep pink.

The winged or migratory forms are yellowish green, with antennae, head and thorax black. There is also a dark spot on the top of the abdomen. The legs, honey tube and cauda are slightly dusky green.

The honey tubes of all the forms of this species are much shorter than those of the Green Apple Aphis.

Remedies.

Same as for Green Apple Aphis.

THE HOP-PLUM APHIS.

(*Phorodon humuli* Schrank.)

Among all of the insect pests of the hop none seem to be as serious as the so-called hop aphis. In all probability its native home is in Europe, where it feeds on sloe, plum and both cultivated and wild hops. The eggs were probably brought to America on imported plum trees and by the same means have been introduced into the various parts of the United States.

The Hop Aphis was apparently first mentioned in literature about 1752, but not until 1801 did it receive a scientific name. It was probably not introduced into the United States until the late fifties; but from that time on it has received considerable attention. Dr. C. V. Riley, former chief of the national Bureau of Entomology was the first person who worked out, with the aid of several competent assistants, the complete life history, the work being done in New York State and supplemented by observations in England. Just when this pest first reached the Pacific Coast is hard to say. Prof. Washburn, who was entomologist of the Oregon Station in 1890, found the aphis in a hop yard in Lane county, and it was soon found to be abundant throughout the state.

Observations made by Prof. Washburn and other more recent members of the station staff show that the life history in the Northwest is practically the same as in New York State with possible variations due to climatic conditions.

In California a Mr. Clarke, of the State Experiment Station, has shown a difference of the life history in that state. There the insect, in part, at least, remains over winter on the male vines. In New York, Wisconsin and the Northwest, the winter is passed in the egg stage on various species of prunes. In Western Oregon and Washington it is possible that some of the wingless forms remain on the roots of the vines over winter, but our observations lead us to believe otherwise. It is generally believed that the Peterson seedling is the principal host in Oregon, and this may be true, but last spring

I examined a thicket of these adjoining a hop yard without finding specimens, while in most distant orchards of Italian prunes they were quite abundant on the underside of the leaves.

Later observations about Corvallis showed that the lice were present in a number of orchards on Italian and Petite prunes.

In this vicinity the life history is as follows: The eggs are deposited on the tips of the twigs during October and November, in more unfavorable seasons they may possibly be deposited in September. From these eggs, about the time the buds are turning green in the spring, hatch the light green stem-mothers. In 1911 they began to appear on the tips of the buds in early March. Usually only a few develop on a single tree, indicating that but few of the eggs hatch. The stem-mothers are wingless and when mature give birth to living young which feed on the underside of the leaves and pass through the same development. We do not know how many generations are produced before the spring migrants appear; but about May these forms appear on the leaves of the winter host plant, and if the hop vines in a nearby yard be examined, solitary winged lice may be found on the leaves with or without young green offspring. By the middle of June wingless forms become abundant on the vines and if not taken care of before that time will do considerable damage. As the burrs develop the lice crawl in under the scales and may escape detection. During the past two seasons special attention was paid to the appearance of the lice on the vines to note any lice that may have remained there over winter or that may have come from eggs deposited on the vines. Up to the time when the migratory forms began to appear from prunes and plums, I was unable to find a single individual. During the summer one can at any time find wingless specimens on the hop vines and none on prunes or plums. About the middle of September winged forms are produced, which migrate back to the overwinter host. These are all viviparous females; they produce the forms which mature, copulate with the males and deposit the black shining eggs on the young twigs about the buds.

The males are also produced on the hop vines but do not reach maturity until several weeks after the females, usually after the hops have been picked. Most of the migrant females will have disappeared from the hop vines by the time the males become developed; and later their offspring, the egg laying females, may easily be found pairing with the males on the prune and plum trees, the males having also migrated from the hops.

Description of Various Stages.

The Stem-mother.—Collected on Silver prune, April 10, 1911, with 15 or 20 young; yellowish green in color, with more or less indistinct lines of darker green along the center of the back. Body length about one-twelfth inch, antennae about one-third the length of the body.

The Spring Migrant.—(Plate IV, fig. 1.)—Collected June 1 and June 23 on Silver prune in orchards about Corvallis and first week in June in hop yards along Willamette River. General color green with dusky and black markings. Head and thoracic lobes black. Abdomen with a series of transverse black bands, the first three being broken in the middle so as to give the appearance of two rows of spots. Length of body about one-fourteenth inch. Honey tubes about one-fifth the length of the body.

Wingless Female Summer Generation.—(Plate IV, fig. 2.)—Collected on hop vines at various times during summer months. General color dark yellowish green and with several indistinct green lines extending along the back. Second antennal segment with a slight projection on inner side. Body length about one-twelfth inch. Honey tubes about one-fifth as long as the body.

The Fall Migrant.—Collected on hop and Italian prunes in October, 1911. General color, dark yellowish green, and perhaps a little darker than the spring migrant. The markings of the abdomen are similar but are not quite so detailed. In other respects the two forms are practically the same.

Oviparous or Egg-laying Female.—Collected on prunes during the first week in November, 1911, pairing with winged males. General color dark green with a slight yellowish tinge, giving them a mottled appearance. Nectaries much shorter than in other forms and measure about one-eighth as long as the body. Length of body about one-tenth inch.

Winged Males.—Smaller than any of the other forms and darker in general color. Antennae, head, legs, thoracic shield and nectaries dusky to black. Thorax and abdomen green. Abdomen with a varying number of transverse stripes, the three or four just in front of the nectaries forming a dark spot. Just back of the nectaries and above the base of the cauda may be found another transverse band.

Remedies.

On prune and plum use same sprays as for Green Apple Aphis.

On hops a number of sprays have been tried in comparison with whale oil soap and quassia chips, but so far the old time spray seems to be the most efficient.

At the request of one grower a combination of whale oil soap and chittem bark was used in comparison with a similar combination of whale oil soap and quassia. These were both prepared by the grower. The first spray was not quite as effective as the second, and in this case we believe that the whale oil soap was entirely responsible for the destructive powers of the spray. No offensive odor of any kind is given off by the chittem bark and by itself it seems to be ineffective.

Whale oil soap alone was not as effective as whale oil soap and quassia chips.

Among the hop growers in Oregon there are two general practices; one is to "strip" the vines and the other is to spray with whale oil soap and quassia chips. "Stripping" consists of pulling off the young shoots and the lower leaves. In this way many of the lice are destroyed by simply being removed from the vines. The practice is then to spray with the whale oil soap and quassia chips.

The formula in general use is as follows:

Whale Oil Soap	10 pounds.
Quassia Chips	5 pounds.
Water	100 gallons.

Place the quassia chips in a sack, cover with 8 or 10 gallons of water and soak 12 to 24 hours. Then bring to a boil, remove the chips, add the soap and boil until it is dissolved. Add water to make 100 gallons. If preferred, the grower may prepare his own whale oil soap after the following formula:

Potash Lye	1 pound.
Fish Oil	3 pints.
Water	2 gallons.

Dissolve the lye in the water; when boiling hot, add the oil and boil about two hours. Add water to make two gallons. Each pound of the soap thus made should be dissolved in 8 or 10 gallons of water. "Black Leaf-40" is now being used quite extensively and gives uniformly better results.

The time of spraying varies with the appearance and abundance of the lice, but in general if a thorough application of either spray be applied about July 1st, a second application is not necessary.

After July 1st nearly all, if not all, of the spring migrants will have left the plums, prunes, etc., and can be destroyed on the hop vines.

THE GREEN PLUM APHIS.

(*Aphis pruni* Koch) (?)

This aphis (Plate IV, Figs. 5 and 6) is distributed throughout the Willamette and Umpqua valleys. During the spring months of 1912, in the vicinity of Roseburg, prune trees were so heavily infested as to have practically every leaf curled to such an extent that the damaged trees were noticeable for a considerable distance.

We have not been able to work out the life history of this species any further than to find that in the early spring just as the buds are opening the young lice appear and begin to settle on the leaves. The eggs have not been observed but they must be deposited on the prune and plum trees in the fall.

By May 1 the lice become abundant in single colonies, but with the exception of the Roseburg district, the colonies have not been found very abundant.

At that time the young are pale green; as they continue to grow, black transverse markings appear on the body and later the entire insect changes to a dark red with a large, dark, more or less shining, spot upon the back.

The under side of the body is a deep red; the antennae, legs and nectaries are opaque green with dark markings. Cauda dark red at the base with a black tip. The nectaries measure about one-third the length of the body. This form measures about one-twelfth inch in length by one-eighth inch wide, and is evidently the form which produces the pupae. The pupae begin to appear about the first week in May and do not at all resemble their large broadly oval mothers.

They are green in color with darker green markings which take the form of a capital Y. The handle lies along the centre of the back with the forks running parallel to and adjoining the wing pads.

The pupae remain in this stage for a short time and then change to the adult winged forms, which are known as spring migrants.

The general appearance of this form is: General color, dark green or black; antennae, legs and back mostly dark green; a lighter green surrounds the darker colored portions.

The antennae measure about two-thirds the length of the body and the nectaries about two and a half times as long as the tarsi.

The latest date for collecting this form is June 30, 1911.

Remedies.

Use same recommendations as for Green Apple Aphis.

THE BLACK CHERRY APHIS.

(Myzus cerasi Fab.)

This insect is quite generally distributed throughout Oregon and sometimes is so abundant as to cause a large number of leaves to become badly curled. We have made no attempt to work out the complete life history further than to learn that lice can be found on the cherry at all times of the year in one stage or another.

One of the most interesting facts in connection with this species is the rapidity with which it multiplies and spreads. During the spring of 1911 careful search was made for the early appearing individuals but only isolated stem-mothers and colonies could be found up to the first of July, when the spring migrants began to settle and start colonies on all the cherry trees about Corvallis. By August 1 trees upon which no specimens could be previously found were infested with from several to many colonies.

The spring migrants began to appear about the first of June, 1912, and at that time many colonies were to be found on trees in the vicinity of Corvallis.

Stem-mothers (Plate IV, fig. 3), with numerous young collected on cherry near Corvallis, April 4, 1911. The newly hatched stem-mothers were first observed March 1, indicating that in favorable years the young hatch early in March. However, in any locality we are led to believe that the eggs begin to hatch with the opening of the buds. At first they feed about the base of the flower or leaf cluster and may or may not crawl into the leaves before producing their young. When first hatched the young lice are dark brown in color gradually turning to a deep shining black in the matured specimens. The antennae and legs are lighter and under a hand lens appear a dusky brown. The antennae extend to about the middle of the broad oval body. The nectaries are about one-fourth the length of the body and point inward; tips slightly curved outward.

The Spring Migrant.—(Plate IV, fig. 4.)—General color shining blackish brown; antennae opaque to black; legs dusky except joints where they are deep black. The wings are hyaline with light veins. Migratory forms can be found at almost all times during the summer months, but only during the period of spring migration are they abundant. July 15, 1912, ten twigs badly infested with lice were examined and only winged individuals were found.

The wingless summer forms can be found on the leaves at all times and during the season of 1912 they were very abundant up to the middle of July, when their insect enemies became numerous and the aphids became correspondingly less abundant. July 26 many twigs showing injury were examined, but not a single live aphis could be found.

When first born the young aphids are light brown in color but grow darker as they grow older. When mature they are shining black in color and measure about one-thirteenth inch in length.

In the early fall the lice become abundant again, when winged individuals known as fall migrants appear in the colonies. Flying to new locations these

start colonies from which later appear the winged males and the unwinged egg-laying females.

The Eggs are deposited on the young twigs and water sprouts usually at the base of a fruit spur. We have examined many twigs in the search for them and have never found more than five eggs upon the same spur. The bark about the base of a spur is more or less wrinkled and the eggs are deposited in the crevices formed by these wrinkles.

Remedies.

Use same recommendations as for the Brown Aphis of the apple.

THE GREEN PEACH APHIS.

(Rhopalosiphum persicae Sulz)

This aphis (Plate V, Figs. 3 and 4) was reported in Oregon for the first time in 1912, and we are unable to give any reliable data except that at the present time it is only known to occur east of the Cascade Range, and has been reported from the Milton-Freewater district and from Hermiston.

Specimens have been received from both of these places where they are said to appear in great abundance every spring.

Gillette and Taylor (4) have worked out the life history of this pest in Colorado, and they have found it quite injurious at different times. The nature of the injury is given as follows:

When the peach trees bloom, this louse often attacks the blossoms in numbers sufficient to blight them. After the fruit forms they sometimes attack the young peaches in sufficient numbers to cause them to wilt and drop. They also attack the leaves causing them to curl and turn yellow in color; if the attack is very severe, many of the leaves drop.

The food plants of this louse are variable and number a hundred or more These include most of our fruit trees, or garden plants and many weeds. Gillette and Taylor have observed the eggs upon peach, plum, choke cherry, prune, nectarine, tame cherry, apricot and sand cherry.

Life History.—This aphis spends the winter in two stages, either in the eggs on the twigs of fruit trees or else as wingless lice upon vegetables and weeds that remain green through the winter.

The eggs hatch in the spring and the stem-mothers are nearly full grown by the time the buds open. At that time they are pink in color and can be found feeding in the blossoms. The later generations are light green with dark green markings on the body. As in the case of other species of this group, winged migratory females appear in May and June and fly about, establishing new colonies.

Remedies.

About a week before the buds open, spray the trees with "Black Leaf-40" (1-800) or kerosene emulsion ordinary strength. If the peach trees are to be treated with lime-sulphur for twig miner or mites, use a combination spray of lime-sulphur diluted (1-15 or 20) plus "Black Leaf-40" at the rate of one part to 800 parts of the diluted lime-sulphur.

If the lice become abundant after the blossoming period, spray as for the Green Apple Aphis.

THE BLACK PEACH APHIS.

(Aphis persicae-niger Smith)

While we have had a few unauthentic reports of this aphis (Plate V, Figs. 5 and 6), not until the present season have we been able to secure specimens and observe the nature and extent of the injury.

We have not been able to find any infestation east of the Cascade Mountains, nor can we find an orchardist who has.

In the western part of the state specimens have been received from Eugene, Roseburg, Ashland and Corvallis. At Corvallis, where several orchards were found to be badly infested, the terminal shoots in several instances died as a result of the injury.

The young lice appear upon the twigs before the buds open and completely cover them. As the buds open, some of the lice migrate to them, feeding upon

(4) Bull. 133. Colo. Exp. Sta.

the leaves and tender parts of the blossom. The blossoms thus attacked become withered and fail to mature. The leaves curl and draw close up to the twigs, giving the trees a very unnatural appearance. Trees at a distance closely resemble those that are suffering from California Peach Blight.

Life History.—The life history of this insect has never been completely worked out, and neither have all the stages been observed.

In the eastern part of the United States, and probably in Oregon, the lice migrate to the roots of peach trees where they remain protected through the winter. In the spring a partial migration takes place and the lice crawl upward to the terminal shoots of water sprouts and branches.

Until nearly full grown the young are amber or chocolate colored. After molting for the last time they appear shining black; hence, the orchardist should have no trouble in distinguishing them from other plant lice which get on peach trees.

All of the first lice are wingless. Winged forms begin to appear about the first of May, and these all migrate so that by midsummer no lice can be found on the trees.

We have had no opportunity to experiment with remedies, but upon our recommendation one farmer near Corvallis sprayed his trees with "Black Leaf-40" in May and claims to have killed all of the lice present.

THE CURRANT APHIS.

(Myzus ribis Linn)

Perhaps no aphis is more easily detected by its work than is this species, feeding on the underside of the leaves and causing them to curl and turn red so that they appear as scarlet bladder-like pseudogalls. The injury begins to show in the spring almost as soon as the leaves are out. Small red patches show on the leaves, and at those particular places the deformation starts and increases with the increasing numbers of plant lice and an extension of the feeding area.

As a rule, very little attention is paid to this insect although it not only causes the bushes to look unhealthy but also causes the leaves to turn into pseudogalls and the fruit to ripen prematurely. The injury to the leaves alone must certainly be very serious as they become so deformed toward the latter part of the summer as not to function properly and the bushes lose much of their natural vitality.

In our observations we have also noted that they may injure gooseberry bushes as seriously as currants, though this injury does not seem to be general.

Description and Life History Notes.

The Stem-mothers (Plate V, fig. 1) hatch from over-winter eggs just as the buds begin to show green in the spring. Each minute yellowish green larva seeks a feeding place on the opening bud. As the leaves open out it crawls to the underside of a leaf where it continues to develop and when full grown produces alive numerous young aphids which pass through the same process.

In the Willamette Valley the eggs hatch about March and by the middle of April the gall-like formations begin to appear on the leaves.

April 19, 1911. Stem-mothers were plentiful on the bushes in the station orchard and from 15 to 25 young were present.

When mature the stem-mothers are lemon-yellow in color and measure about one-tenth inch in length by half that in width. Along the center of the back is a row of dark green spots, apparently one for each segment; extending out from these along each segment are indistinct dark green markings which, with the central spots, form indistinct stripes or bands. Under a high power microscope numerous long hairs with knobbed tips can be seen on the body.

Spring Migrants (Plate V, Fig. 2) collected on currant, Corvallis, Oregon, May 17, 1911. Very abundant. General color black and green, the head and thorax being black while the abdomen is green. Body dark green with five broken bars across abdomen. These bands are not regular but are composed of a number of irregular ragged parts. The fifth band, which extends across the abdomen at the base of nectaries, is quite heavy and the ends enclose the bases of the nectaries. Along each side of the body one may find a row of three or four black spots.

Fall Migrant, collected at college farm Nov. 1, 1911, on underside of leaves of currant. General color reddish green, antennae, head, thorax and nectaries black. Abdomen green with a pinkish tinge and marked on back with from two to four broken bars of black. On each side of the abdomen may be found a row of four black spots. The base of each nectary rests in the end of one of these. Femora and tibiae in middle dusky green, ends deep black; tarsi black. In other respects similar to the spring migrant.

Egg-laying or Oviparous Female, collected on the underside of currant leaves in copula with males, November 20, 1911. General color yellowish green mottled with darker green. Size slightly smaller than the viviparous forms, but otherwise similar in appearance.

Eggs, when first deposited, light green and later changing to shining black.

Males, collected Nov. 20, 1911. General color dark green; abdomen dark green with dusky or black markings and with from 3 to 4 black spots on each side. Size about one-half that of the winged female, but with antennae longer. Wings almost as long as those of the migrant forms but narrower.

Remedies.

Spray with combination spray of lime-sulphur (1 to 15) plus "Black Leaf-40" 1 part to 900 parts of the diluted lime-sulphur. This spray should be applied in the spring just as the buds are opening.

If later applications are desirable, use "Black Leaf-40" diluted one part to 900 parts of water. If the leaves are out, the spray must be made to reach the underside where the lice are feeding.

THE GOOSEBERRY APHIS.

(*Aphis grossulariae* Kalt.)

During the spring of 1911 an aphis corresponding to the description of the above was found quite abundant in the vicinity of Corvallis, feeding on the petioles of the leaves of the terminal shoots (Plate V, Figs. 3 and 4). Observations were made at intervals until the winged forms appeared in June and July. They then disappeared and were not again found on the gooseberry until October 11. By late June the leaves became quite withered, and while no injury to the fruit was apparent the bushes must undoubtedly have suffered as a result of the deformed leaves.

Upon the leaves of the same bushes the currant aphis was found in abundance. They were again present in 1912, but not in such numbers. The general color is dark green to black with the body covered by a fine white powder or wax. The antennae and nectaries are dusky green. The winged specimens are dark green to black in color with two large transparent wings.

Remedies.

Use same spray as for the Currant Aphis.

SPRAYS FOR APHIS.

The sprays in common use against plant lice at the present time may be placed under four common heads. These are, in order of importance: Tobacco sprays, emulsified oil sprays, soap sprays and lime-sulphur.

The Tobacco Sprays are more commonly used than the others and are generally more effective.

"Black Leaf-40," a commercial spray manufactured by the Kentucky Tobacco Products Company, Louisville, Kentucky, has been found quite satisfactory alone, and in combination with lime-sulphur. Directions for use are usually given on the containing vessels. When combining with lime-sulphur, first dilute the lime-sulphur to the required strength and then add the "Black Leaf-40" at the rate of one part to 800 or 900 parts of the diluted solution. The proper time for the use of the combined spray in the case of trees which produce blossoms prior to the opening of the leaf buds, is in the spring just as the buds begin to open. Trees upon which the leaf buds open first may be sprayed to advantage just after the buds open. (For proper time of spraying see plate.)

When it is desirable to use the "Black Leaf-40" without the lime-sulphur, the addition of a small amount of soap will aid the spray in spreading over the leaves.

Our experiments with the combined spray when used against the San Jose Scale and moss, show that the scales die sooner than in the case of lime-sulphur alone, and the moss dies just as quickly.

After the leaves come out and it is not desirable to use a combined spray, the "Black Leaf-40" is effective against all kinds of aphis and on all plants.

Where the leaves are badly curled, the spray should be applied with great force in order to force it into the folds where the plant lice are working.

Emulsified Oil Sprays consist of oils emulsified with soap, the most common one being made from kerosene. **Kerosene Emulsion** is usually prepared as a stock solution and then diluted to the required strength for spraying. The necessary materials are as follows: Hard soap, half pound; water, 1 gallon, and kerosene, 2 gallons. The soap should be dissolved in boiling water, and when thoroughly dissolved the containing vessel should be removed from the fire and the kerosene added. The mixture should then be thoroughly agitated until it is creamy white. This is best done by a hand pump, forcing the mixture through the hose and back into the container. This then forms three gallons of stock solution which can be diluted to the required strength by adding given amounts of water. To get the amount for any given percentage, divide the percentage into 200 and then subtract three from the answer, and we have the amount of water necessary to add to each three gallons of stock solution for that percent.

Example: We desire a 15% solution.

15)200

13 1-3—3=10 1-3 gallons of water to be added to three gallons of stock solution to get a 15% solution.

Soap Sprays are made from several kinds of commercial soaps, some of which are specially prepared. Whale oil soap is generally used, and in combination with quassia chips makes a splendid spray for use against the hop louse. Alone, if thoroughly applied at the rate of one pound to six or seven gallons of water, it is quite effective.

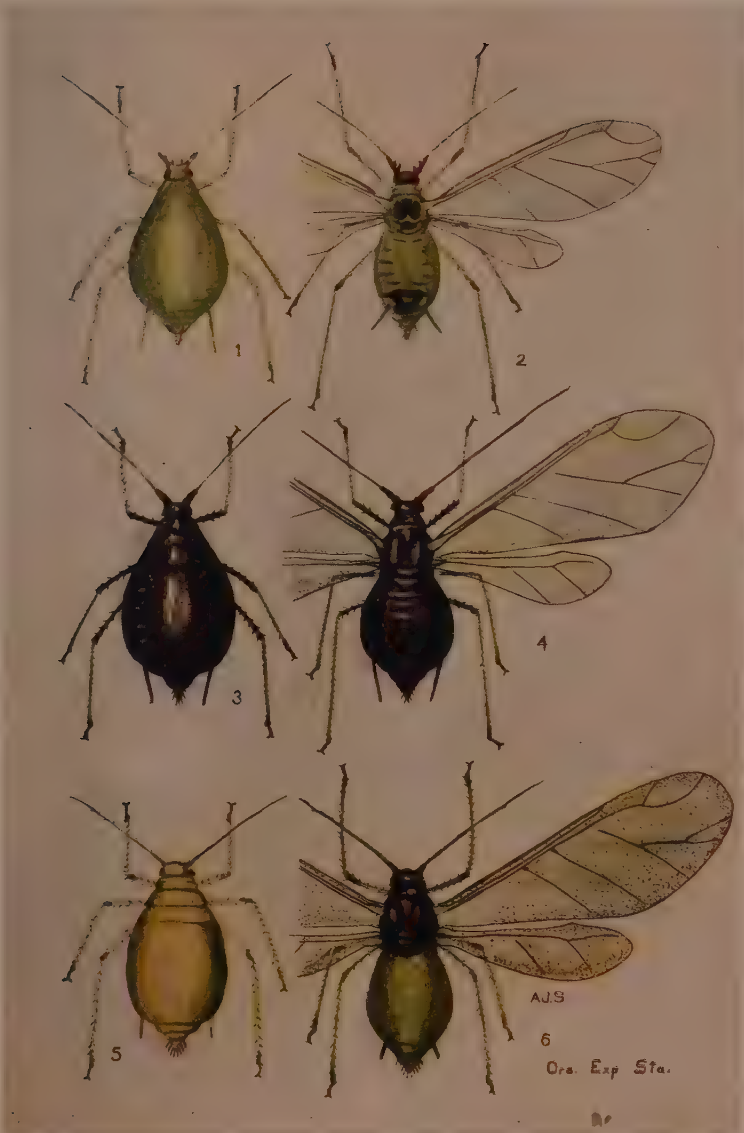
Lime-sulphur as an aphis destroyer has with us given very poor results, both with the eggs and with the lice. Lice just hatching from the eggs can sometimes be destroyed, but we have observed that although most of the over-winter eggs are destroyed, there are enough left to cause a serious infestation in the spring. Adults treated with concentrated and diluted lime-sulphur in most cases fail to show any ill effects whatever.

In the case of the Woolly Aphis of the apple, laboratory experiments have gone to show that ordinary applications of lime-sulphur will not kill it in any stage. On the other hand, orchards that receive one or more thorough applications of lime-sulphur are not as badly infested above ground as the unsprayed trees. This seems to indicate that the lime-sulphur is more or less beneficial.

General Recommendations.

To destroy stem-mothers in the spring, spray just as the buds are opening with lime-sulphur (1-10) plus "Black Leaf-40" (1-900), or "Black Leaf-40" (1-900), or Kerosene emulsion 15% solution, or Whale Oil Soap, 2 pounds to 4 gallons of water, if none of the other sprays can be secured. This applies to all fruit trees and bush fruits.

To destroy the lice after the foliage is out, spray with "Black Leaf-40" (1-900) plus 1 pound of soap to each 100 gallons of spray, or Kerosene emulsion 15% solution, or Whale Oil Soap, 2 pounds to 4 gallons of water.



The Plum-Hop Aphis, figures 1 and 2. The Black Cherry Aphis, figures 3 and 4. The Green Plum Aphis, figures 5 and 6.

The Green Currant Aphis, figures 1 and 2. The Gooseberry Aphis, figures 3 and 4. The Black Peach Aphis, figures 5 and 6.

THE SHOT HOLE BORER OF THE NORTHWEST; OR THE PEAR BLIGHT BEETLE OF THE EAST.

(Xyleborus dispar Fabricus.)

By H. F. WILSON.

INTRODUCTION.

During the spring and summer months of each year numerous inquiries are received relative to this insect. Orchardists in general have believed that many trees, especially prune and cherry, were being destroyed by the ravages of this beetle. In one instance I visited a young apple orchard which appeared to be perfectly healthy and yet a number of trees were badly attacked. Many young trees set out during the previous fall of 1909 or winter following, were found dead during the fall of 1910, and in certain localities every one of these was infested with the shot hole borer. A number of prominent entomologists of England and Europe claim that many healthy trees are destroyed by this insect in years when it is abundant. With the idea of fully determining, therefore, the importance of this insect as an enemy of fruit trees in the Northwest, plans were made for a study of its habits, life history, etc. Observations and breeding-cage experiments were carried on, both in the laboratory and in the field during 1911, and were checked over during 1912.

Fig. 1. Heart Rot Fungus *(Schizophyllum sp.)* in cherry, issuing through burrows of *(Xyleborus dispar)*.

During 1911 there appeared but a single generation, and as this seemed contrary to all reports from Europe and the eastern part of the United States, more careful observations were made in 1912. In Oregon we have been unable to find but a single brood, and if a second one occurs at all there is not a particle of evidence to show when it appears.

After having made several hundred observations in orchards where the borers were found, I do not believe that under ordinary conditions healthy trees are attacked in the Northwest.

Believing that it will not pay orchardists to apply any washes or sprays as a preventive, no experiments have been carried on for the control of this pest. When the study of this insect was first undertaken it seemed desirable to determine whether the trees attacked were not injured by the fungus which is used by the beetles as food. Later developments seemed to show that the results would be of little practical value and these studies have been discontinued.

Classification and Synonomy.

The *Scolytidae* or engraver beetles, constitute a large and important

group of beetles, many of which are very destructive to forest trees. From an economic standpoint the members of this family may be divided into two general groups, those attacking healthy living plants and those attacking plants in a more or less sickly or *dying* condition. Observations made in Oregon by the writer indicate that *Xyleborus dispar* is distinctly a member of the second group.

Fabricius, who is credited with having first described this insect, placed it in his genus *Apate* with the species name of *dispar*. The species name seems to have been taken from the disparity of the males and females.

The original description made in 1792 is given in Entomologia Systematica (Fabricius), volume I, part II, p. 363, as follows:

No. 11. Apate—ater thorace gibbo antice scabro tibiis testaceis *dispar*.

Habitat in Germaniae truncis Dom. Daldorf. Praecedentibus minor. Thorax gibbus, scaber subvillosus. Elytra striata, entegra, Pedes nigri tibiis testaceis.

Mas duplo minor thorace planiore.

Under the name of Scolytus pyri, Peck (Massachusetts Agricultural Journal, 1817) describes what is evidently the same species in an article on the Insects which destroy the young branches of the Pear Tree, and the leading shoots of the Weymouth Pine, as follows:

"For several years past the ends of the branches of the Pear Tree have been observed to perish suddenly, insomuch that it has been attributed to lightning. Mr. Lowell, believing it was caused by insects, on examining the dead part of the branch, proved the correctness of his judgment. He presented me one of the insects with a part of the branch, which contained it in its perfect state; which is the occasion of this communication.

"The branches attacked by this insect are known by their leaves withering and turning brown. This happens in June or July; the insect has then passed through its pupa or chrysalis state and acquired its perfect form. As it is only after it has arrived at this period that it can continue the species, it is probable that it deposits its eggs before the month of August is passed. The egg is probably deposited behind a bud, i. e., between the bud and the stem, and is hatched soon after; the larva or grub eats its way inward through the sap, into the hardest part of the wood.

"The piece of a branch which I had was three years old; it had, therefore, one layer of sap and two of wood. The grub had eaten the inner layer of wood, a part of the medulla or pith, and about half of the second layer of wood, in a circular direction, leaving the alburnum or sap-wood untouched, except at its exit. This is shown at Fig. 2, which represents the end of the wood at the place where the insect was lodged. The external dark circle represents the bark; the centre, the medulla; the other dark portion is the excavation made by the grub.

"The genus to which this insect belongs is called Scolytus. Of this genus it is an undescribed species. It is precisely 0.1 or 0.10 of an inch in length, .04 in diameter; of a deep brown color, the legs and antennae paler and of a rust color; the thorax in front is rough with small tubercles, which point upward and is studded with erect bristles, as are also the elytra or wing-cases and other parts of the body. The elytra are striated with slightly impressed points, and between the series of points are rows of bristles. The plane of the anterior opening of the thorax, which receives the head, is nearly at right angles with that which joins the abdomen, so that the head is entirely underneath. The eyes are oblong, and the antennae inserted at their lower and anterior edge. This species may be called Scolytus pyri.

"The mischievous effects of this minute insect are observed in June and July; the dead part of the branches of the pear tree should be immediately cut off and burnt without delay, as the insects have not then left them."

Eichoff (1879) includes in the synonomy of this species *(Bostrichus brevis)* Panzer; *(Bostrichus thoracicus)* Panzer; *(Bostrichus tachygraphus)* Sahlt. and *(Bostrichus ratzeburgii)* Kollar.

Professor E. J. Krause, an authority on this group of Coleoptera, is of the opinion that the last named group of synonyms are unsettled and that *Scolytus pyri* Peck is the only definitely known synonym.

At various times this beetle has been placed under the genus names, *Apate*, *Bostrichus*, *Tomicus*, *Xyleborus*, *Anisandrus* and *Xyletorus*.

History.

In reading the many accounts which have been written of this insect and its work, I have found them so variable that most of them taken separately might cover some fifteen or twenty wood boring insects. Great difference of opinion exists as to the condition of the trees attacked. European writers seem to find sufficient evidence to show that healthy trees in large numbers are frequently attacked and killed. Dr. Fletcher, late entomologist of Canada, has frequently written of serious injury to apple and plum and mentions that this beetle with others carry common pear blight fungus. If the beetles

attack healthy trees this could readily happen, as we have made numerous cultures of heart rot fungus by allowing the beetles to walk over culture media in petri dishes.

In the eastern United States the beetles are thought to attack only unhealthy trees. In the Willamette Valley in Oregon all the evidence which we can discover shows that only unhealthy trees are attacked.

In the original description by Fabricius, 1792, there is nothing to denote the habits of the insect. Fabricius, however, must have been acquainted with both sexes on account of the name given.

The widespread distribution of this insect in Europe would indicate its being native to that country. We can only theorize on the time and means of importation into the United States, but the time must have been several years prior to 1816. About this time the insect was attracting some attention in Europe and has continued to receive more or less attention by different writers up to the present date. Some European entomologists have worked on the life history and habits, and their drawings and descriptions of the insect and its injury correspond to conditions in Oregon, not considering the health of the trees attacked. One notable difference is found, however, in the fact that they write of two well defined generations, while only one is found in the Willamette Valley.

Space is too limited for a discussion of all of the scientific articles on this insect, the most important of which are by Hartig, Kollar, Ratzeburg, Eichhoff, Hubbard, Schwarz and others.

Kollar, 1837, gives a very complete treatise on the habits and life history, and his statements are born out by what is found in Oregon. He believes that owing to the long time necessary for development a second generation would be unable to mature.

Eichhoff, 1881, gives the most complete account of this insect, reviewing the work and writings of earlier authors. He calls attention to the longevity of the females and states that there are two generations yearly.

Miss Omerod, 1889, states that previous to that year this insect was quite rare in England. According to other reports of Miss Omerod, the beetles must have developed in great numbers.

Judeich and Nitsche, 1895, state that there are two generations annually. The beetles of the over-winter generation fly in April and May and those of the second in July and August.

Hartig, Hubbard and Smith wrote more from the standpoint of the food used by insects of this group. A discussion of their writings with those of later writers will be found in the discussion upon the feeding habits of the larvae and adults. According to observations made by various writers, all kinds of trees both in a healthy and unhealthy condition, are subject to attack. They must contain sap, however, in a more or less fermented condition, in order to develop the food.

Distribution.

This insect is found in nearly all parts of Europe and England and is gradually spreading into certain sections of Canada and the United States. It was first noted in this country by Peck, in Massachusetts, 1816. In 1842 Harris gave an account of its depredations in Massachusetts, and in 1860 Dr. Fitch reported it from New York. It was next reported from Canada, and in 1899 Lugger states that it was one of the injurious beetles of Minnesota.

Occurrence in the Northwest.

The first reported injury in the Northwest which was in Clarke county, Washington, came in 1901, where a grower thought that a great many prune trees were being killed by the beetles. At the same time the beetles were working in Oregon near the city of Portland. In looking over the many inquiries which have been received during the past ten years it is interesting to note the gradual spread of the insect up the Willamette Valley until now it is at Junction City, a distance of 125 miles south of Portland.

At the present time the distribution extends through the lower part of

the valley on both sides of the river as far as the foot hills. The infested territory is increasing quite rapidly and the borers will in time undoubtedly spread over the entire western part of the state. From Portland to Salem, a distance of 53 miles, they are very abundant across the entire valley, and few dying trees escape their attack.

Nature and Extent of Injury.

The real injury caused by these beetles seems to be almost, if not entirely, secondary in Oregon. In Europe numerous writers have given detailed accounts of injury to all kinds of fruit and deciduous forest trees. Many of our orchardists upon finding sick and dying trees with the shot hole borer working in them have attributed the cause to the beetles.

By visiting many of these places and explaining to the orchardist the true conditions, we have convinced them that the trees were suffering from some fungous disease or improper soil condition.

The beetles may help to kill the trees and in some cases might cause the death of trees which would have recovered from the disease had the beetles not been present. In the case of young trees, only one or two years old, this could readily happen, as the burrows extend almost entirely around the trees and close to the inner bark. (For example see Fig. 2.)

In the summer, after the beetles have completed the burrows, such trees can easily be broken off at the point of injury. In connection with the injury one can readily see that since the beetles do not work in the vital parts of the older trees they would only injure them in such a manner that the trees would become honey-combed and be broken off by the wind. There then remains the possibility of distributing injurious fungi which might spread into healthy tissues from the burrows. We have observed that where the burrows are made, a darkened area extends for several inches up and down the tissues of the wood. Especially is this true of trees with an abundance of sap. (For average example of injury see Figs. 2 and 3.)

Fig. 2. The Shot Hole Borer. Burrow in young cherry tree and adults in hibernation.

Life History.

The winter is spent in the adult stage. Both males and females hibernate in the burrows from July and August until the following spring. They emerge during the last of March and first of April and migrate to sick and

dying trees, where the burrows of that season are to be made. The entrance hole is usually made about a bud scar or in some roughened place. The beetles have no trouble in picking out the sick trees, a fact which can readily be seen from the following incident. In May of the present year I visited an infested prune orchard near Salem, Oregon, where the owner, in order to combat the theory that healthy trees are not attacked, showed me two fine looking trees where the beetles had attempted to enter but had been destroyed by himself. The places where they had gnawed some of the bark were examined and on the surface it looked as if the beetles did attack sound trees. The bark was without an unhealthy indication of any kind and the foliage appeared as healthy as any in the vicinity. Many other infested trees were visited and all found to be diseased. We finally returned to the first two trees and cut into the bark. In the case of both trees the inner bark and cambium layer was black and gave off the odor of sour sap. A small gum pocket was found on one, which to a slight extent resembles gummosis of the cherry. The owner of this orchard is now convinced that only trees in a diseased condition are attacked.

Fig. 3. Example of injury to young cherry tree.

The Adult.

The adult bores directly through the bark and into the wood tissue for a quarter of an inch or more and then begins the construction of branch burrows extending at right angles to the main burrow and with the grain of the wood. These channels are all about one-twelfth inch in diameter and from three-quarters to two and a quarter inches in length. The laterals also vary considerably in length.

Evidently the burrows are entirely constructed by the females, which must of necessity be fertilized before leaving the tree containing the original burrow. As the males do not have underwings and supposedly cannot fly, just how the mating is accomplished I am unable to say. If the females are fertilized before leaving the old burrow, we can understand why there are many more females than males. The females are only fertilized once, as the males can not fly to the new channels. In April, 1912, I observed a chestnut tree which contained many old burrows of this insect as well as many new ones just started, with females in both types. In each burrow a female was found at the entrance, and with most of them were observed males in the act of copulation. In this instance the males completely fill the mouth of the burrow, the body being bent so that both the head and tail were in the entrance. The back of each insect extended above the bark so that they looked like rounded scales or protuberances on the bark. The males in this position could

The Larva.

The Larvae (Fig. 5A) when first hatched are slightly longer than the eggs, and lie in a curved position. They are pure white in color but after they start feeding the alimentary canal shows black through the body wall. They are capable of considerable movement, but probably do not move far from the original hatching place, as their food supply is always ready and at hand. The larvae require about four weeks for complete development. At the end of that time they void all excrement from the body and are clear white in appearance; they lie end to end in the burrows and are nearly as large as the diameter of the burrow.

Description.—Length of body, 5 mm.; width at widest part, 1.45 mm. Head subelliptical, quite small and white except mouthparts which are brownish. Body white, curved and cylindrical except a slight tapering at caudal end and without legs. The head and each body segment except the last bears a number of transparent nipple-like tubercles, which vary a great deal in size and shape; the body also carries a number of short hairs which seem to be of two general kinds. One set is simple and the other set appears to be capitate.

The Pupa.

The Pupae (Fig. 5B) are found from the second week in June until the first of August. About four weeks are required for the pupal stage, lasting from June 8 until July 6. The pupae of the males and females are easily separated, as the first are much shorter. The pupae remain in the burrows for three weeks or more without change. When the change to the adult is made the beetles are still whitish and they do not become completely dark for several days.

Description.—Length of body, 4 mm.; width, 1.5 mm., at middle of thorax. Body uniformly white throughout, sparsely hairy and roughened by numerous large thick tubercles. On the last and next to last segments are to be found two or three pairs of transparent nipple-like tubercles similar to those found on the larvae.

Host Plants

This insect will apparently work and develop in all kinds of deciduous fruit and forest trees and has been reported as working in conifers. I cannot attempt to give a complete list of host plants owing to the fact that all the literature on the subject was not available. The following fruit trees are reported: apple, pear, quince, cherry, prune, plum, hawthorn, apricot, white hawthorn, grape and pomegranate. The following forest trees are reported: oak, elm, birch, ash, yoke elm *(Carpinus betulae)*, alder, plane tree, maple, chestnut, pine *(Pinus silvertris)*, tulip tree, hemlock, cedar, beech, poplar and willow. Nearly all writers on this subject agree that the beetles favor dying trees to healthy ones, and several of them state that freshly cut logs and stumps are excellent breeding places. In Oregon we have found them working in cherry, prune, apple, pear and chestnut. Cherry and prune are attacked more because those two trees appear to be more subject to diseased conditions than any of the others. Many cherry trees, especially young ones, die each year from the disease known as cherry gummosis. Prune trees are found growing in all manner of places in the Willamette Valley and a great many in unsuitable surroundings. Naturally many of them succumb, and in addition there seems to be a disease similar to that of the cherry which destroys a great many. Both of these fruits develop what is commonly known as sour sap, a condition known to be favorable for the development of the fungus food upon which the larvae feed.

An occasional apple orchard is found infested, and I have observed a few pear trees showing attacks of this insect. In the vicinity of Oregon City,

Clackamas County, a number of orchardists are growing a few chestnut trees. Conditions are such that the trees do not thrive and they gradually die down. In some of these that are still alive heart rot seems to have filled the centre of the tree, and the beetles continue working in them year after year until they finally die. One of these trees cut down at the time of my visit near Oregon City was almost completely honey-combed, and in places the new burrows produced great numbers of eggs, larvae and pupae.

The Food of Xyleborus Dispar.

The fungus upon which the larvae feed is evidently carried to the burrows by the females, since it appears in each burrow almost as soon as started.

The earlier entomologists seem to have been in doubt as to the nature of the food found in the brood chambers. Schmidberger, 1836, called the food "a kind of Ambrosia" and states that it consists of a substance coming from the wood and prepared by the mother beetle. Hartig, 1844, apparently made microscopical examinations of the food and found that it was a fungus, which he called *Monilia candida*. Goethe, 1895, according to Hubbard, gave an excellent figure of the Ambrosia of *Xyleborus dispar*. Smith, 1896, and Hubbard, 1897, both give discussions on this fungus. In Hubbard's article will be found a very learned discussion. He writes as follows:

"The ambrosia does not make its appearance by accident or at random in the galleries of the beetles. Its origin is entirely under the control of the insect. It is started by the mother beetle upon a carefully packed bed or layer of chips, sometimes near the entrance, in the bark, but generally at the end of a branch gallery in the wood. In some species the ambrosia is grown only in certain brood chambers of peculiar construction. In others it is propagated in beds, near the cradles of the larvae. The excrement of the larvae is used in some and probably in all the species to form new beds or layers for the propagation of the fungus.

"It is not alone, however, the excreta of the living beetles or their young that is required for the development of ambrosia; there must be present a certain amount of moisture or sap, and the sap in most species must be in a condition of fermentation."

As the fungus develops the growth forms into little globules containing the spores.

"The young larvae nip off these tender tips as calves crop the heads of clover, but the older larvae and the adult beetles eat the whole structure down to the base, from which it soon springs up afresh, appearing in little white tessellations upon the walls.

"The growth of ambrosia may in fact be compared to asparagus, which remains succulent and edible only when continually cropped, but if allowed to go to seed is no longer useful as food. In like manner the ambrosia fungus must be constantly kept in fresh growth, otherwise it ripens; its cells burst and discharge the protoplasmic granules which they contain in myriads, and the entire plant disappears as if overwhelmed by a ferment.

"Various disturbances of the conditions necessary to its growth are apt to promote the ripening of the fungus, and this is a danger to which every colony of ambrosia beetles is exposed. If, through any casualty, the natural increase of populous colony is checked, there results at once an overproduction of the ambrosia. It accumulates, ripens, and discharges its spores, choking the galleries and often suffocating the remaining inhabitants in their own food material. The same results may sometimes be brought about by closing the outlets of the galleries through the bark, or by spraying into them kerosene or some other noxious liquid. The inmates of the colony are thereby thrown into a panic, the beetles rush hither and thither through the galleries, trampling upon and crushing young larvae and eggs, breaking down the delicate lining of ambrosia on the walls of the brood chambers and puddling it into a kind of slush, which is pushed along and accumulated in the passageways, completely stopping them in places. The breaking down of the food fungus follows and in a few days the galleries are filled with a paste-like mass of granules or spores or with threads of mycelium, in which the living insects are suffocated and destroyed."

During the last few years several men have worked on the fungus of the Ambrosia beetles, but no definite determination has been given. J. Beauverie, 1910, decides after considerable study that this fungus is a *Dematium* but does not decide upon a specific determination.

Natural Enemies.

Eichhoff, 1881, reports *Calydium filiforme*, *Oxylaunus caesus* and *Hypophlosus bicolor* as found in the chambers of *Xyleborus dispar*, and probably feeding upon the brood and eggs of the latter.

Schwarz, 1891. reports finding *Bactridium cavicolle* in breeding cages of *Xyleborus dispar*, and supposes that they are predacious on the larvae and eggs of this insect. We have as yet found no natural enemies of this insect in Oregon, probably owing to its recent importation.

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THE SMALLER SHOT HOLE BORER.

(Xyleborus saxeseni Ratz.)

This little cylindrical beetle is quite similar to the shot hole borer in appearance, but is only about one-half as large. The burrows are also quite dissimiliar in nature, and on comparison can readily be distinguished. (Fig. 7.)

Fig. 7. *(Xyleborus saxeseni)*, gallery in cherry.

The above species apparently works upon the same trees and under the same conditions as the larger species, and so far as we know, never enters perfectly healthy trees. The life history is not definitely known for Oregon, but in general is about as follows:

The adults reach maturity in the spring or summer, and making their burrows in some diseased tree deposit eggs which later hatch out into small white grubs. These are the larvae and remain in that stage through the summer and winter, transforming to pupae and adults in the spring. The burrow, instead of being a series of short tunnels, is one large cavity with sides parallel and about the width of the full grown beetle. The sides extend straight up and down and the eggs are indiscriminately deposited in a single mass. Just how the larvae manage to retain a hold on the sides of the cavity has not been learned. Since it is believed that this insect attacks only unhealthy trees, methods of treatment have not been studied.

CODLING-MOTH.

(*Carpocapsa pomonella* Linn.)

By H. F. WILSON.

The codling-moth must everywhere be considered an important factor in apple, and to a less extent, in pear growing. It occurs in every important apple growing section of the world, and wherever repressive measures are not employed, annually destroys one-fourth or more of the crop.

Supposed Immune Regions.—The above statement is made notwithstanding the repeated appearances of reports of new or little developed fruit regions which, by reason of some especially favorable soil or climatic condition, are supposed to be **immune.**

Orchardists who are located, or who contemplate locating in such supposed favored regions are cautioned against relying too implicitly upon the continued absence of the codling-moth, unless active, intelligent effort, rather than blind reliance upon an unknown factor, be made to prevent its gaining a good foothold. During the past fifteen years we have seen this idea of immunity dispelled in locality after locality in the Pacific Northwest, and when we consider that the codling-moth is a serious pest in England, on the continent of Europe from Mediterranean regions to the northern limits of apple growing in Siberia, in southern Africa, Australia, New Zealand, Tasmania and China, as well as in the United States and Canada, we are forced to recognize the improbability of perpetually immune regions. Once it gains a foothold the codling-moth will thrive wherever the apple can be grown successfully.

We do not wish to be understood as arguing that the codling-moth will become equally destructive in all localities, or that its prevalence is independent of climatic conditions. Rather the contrary is true, since the seriousness of its depredations varies with both the locality and the season. Temperature is the great factor which controls the abundance of a species in a given locality; hence, as the female moth deposits eggs freely only when the evening temperature is above 60 degrees Farenheit, we should expect to find, as indeed we do find, that the orchards in the coast regions west of the Cascades, and those of the inland plateau sections, are less subject to the ravages of the codling-moth than are those of the inland valleys. This factor is of but little practical importance, however, and should be given scant consideration in the selection of an orchard site. The probability is that as orchards become more numerous, active repressive measures against the codling-moth will become necessary, even in the most favored localities.

Know All Stages.—Efficient spraying operations and the proper application of other repressive measures against the codling-moth are so intimately linked with its habits, and these habits so varying, within certain limits, with the locality and the season, that every grower should become familiar with it in all of its stages. Unfortunately, however, growers do not seem fully to recognize the importance of such information, or consider it too technical and difficult to obtain. Consequently few actually do know it in any other than the larval or "worm" stage, notwithstanding the fact that a "speaking acquaintance" with all stages is easily acquired.

The codling-moth, in common with many other insects, passes through four sharply defined stages during its development, viz.: the egg, the larva or "worm," the pupa, and the moth or adult. All four stages from the egg to the moth inclusive constitute a generation or a "brood," and since this cycle from egg to moth is completed twice during the year, the insect is said to pass through two generations yearly, or to be "two brooded." In some of the warmer apple growing sections of the south three broods are reported. During the winter it exists only in the larval state, but during a greater portion of the summer months it may be found in all four stages.

The Egg.—The eggs, which are laid singly, are minute, nearly circular scale-like objects about one-twentieth of an inch in diameter, pearly white in color and somewhat translucent. They may well be likened to minute trout scales glued to the surface of a leaf or fruit. The surface of the egg,

Plate VI.

Codling-Moth *(Carpocapsa pomonella)*. 1 and 2. Apples showing entrance at calyx and exito side. 3. Apples showing entrance holes of young larvae. 4. Larvae in apple. 5. Adult resting on apple. 6. Cocoon on bark of apple. 7. Cocoon opened and showing larva inside. 8. Open cocoon showing pupa. (Figures 1 and 2, original; the others taken from Bulletin 69 of this station.)

however, is finely wrinkled and so reflects the light that it appears as a minute glistening speck, if the fruit or leaf to which it is attached is held at the correct angle before the eye. In two to four days after oviposition the developing larva becomes distinctly visible as a black spot near the center of this circle and the outline of the whole body is discernible for a day or two before the egg hatches. The eggs hatch in from seven to ten days.

The Larva.—When first hatched the young larva is scarcely one-sixteenth of an inch long. The head is large, black and shining; the body is slender, translucent white in color and marked with distinct black spots, each of which has a minute bristle. Owing to their minute size and to the fact that they usually enter the fruit very soon after hatching, these young larvae are rarely seen. As the larva develops it molts five times; the color of the head and the thoracic and anal shields turn black to brown, and the body acquires a pinkish tinge. The full-grown larva is about three-fourths of an inch long and one-twelfth of an inch in diameter. The duration of the larval stage is from sixteen to twenty-four days.

The Pupa.—Shortly after becoming full grown the larva leaves the apple and seeks some protected spot in which to hide while passing through its transformations from larva to pupa, then to moth. Having found a suitable place, it hollows out a little oval cavity with its jaws and proceeds to envelop itself in a thin tough cocoon of silken threads intermingled with particles of the excavated material. When completed, the cocoon is usually oval in form and about three-fourths of an inch long. When the pupal stage is reached the insect remains in that stage for about three weeks, and then emerges as the adult or moth.

The Moth or Adult.—The moths are really beautiful little creatures. The body is about three-eighths of an inch long and is of a modest greyish brown color. The fore wings when fully expanded measure about three-fourths of an inch from tip to tip, and are of approximately the same color as the body but relieved by inconspicuous, transverse, wavy lines or lighter scales. The hind wings which are entirely covered when the insect is at rest are nearly slate colored and are clothed with long hairs. The most characteristic marking is a large golden brown spot at the posterior outer angle of each front wing. No other insect is known which has this marking and no insect need be mistaken for the codling moth. The males are further distinguished by a narrow pencil of black hairs on the hind wings and an elongated black spot on the upper surface of each front wing.

Owing to their coloring, which resembles closely that of the bark upon which they often rest, and their habit of remaining quiet during the daytime, these moths can very rarely be detected in the orchard. Occasionally one may be seen flitting about the trees at twilight, and very rarely we have observed them resting quietly upon the bark and leaves and even on the ground. When disturbed they start away with a swift zig-zag motion very hard to follow. For the purpose of depositing eggs they normally fly only during the warm nights, and are presumably most active during the twilight period.

Recommendations for Oregon.

Conditions which are found in the eastern states have but little bearing upon somewhat dissimilar conditions found in this state. Early spraying alone will not save the fruit, and it is not only practicable but necessary to fight the second brood. So far as the codling moth is concerned, early applications, after the calyx lobes close are of very little value in western Oregon. In the orchard sections of that region the petals fall from the first week in May (at Roseburg) to several weeks later in sections along the coast (at Astoria).

The first larvae enter the fruit at Corvallis rarely before June 25, so that a period of about six or seven weeks exists between the time of the calyx spray and the time when the larvae enter the fruit. This is in a great measure due probably to the fact that the eggs of the codling-moth are not deposited until the evening temperatures reach 60° F. or above.

At Roseburg, Oregon, the records of the U. S. Weather Bureau for the past ten years were examined and notes made as follows: After May 20, at dusk of each day the temperature is about 60° F. or above. Beginning with June 1 the evening temperature, up to 12 o'clock, does not fall below 65° F. At Roseburg, June 8, eggs, hatched and unhatched, were found with an occasional larva entering the fruit.

At Medford the larvae begin to work in the fruit about the same time.

Recommendations for Spraying in Oregon.—Make at least three applications and in renovating old orchards a fourth will not do any harm.

1. In all sections of the state spray immediately after the petals fall.
2. In all sections of western Oregon it is not necessary to spray two weeks after the first application. Make the second application approximately six weeks after the calyx spray, and the third about five weeks after the second. Where a fourth application is deemed necessary, spray about three weeks after the third.
3. In eastern Oregon spray from two to three weeks after the first application, depending upon the weather conditions. Make a third application five weeks after the second and a fourth two weeks later than the third.

Poisons to Be Used.—Paris green, London purple, arsenate of lime, and arsenate of lead, are the principal arsenites which have been used for spraying. At present the last-named is practically the only one used. The principal brands upon the market at present are Bean's Ortho 13, Better Spray, Grasselli's Star, Lyons', Swift's, and Sherman-Williams. These fall readily into two classes, viz.: the neutral ortho-arsenates and the acid arsenates. In those of the first group the ratio of lead oxide to arsenic oxide is approximately 3 to 1. In those of the second group the ratio is as 2 to 1. The neutral or ortho-arsenates are made by combining lead acetate and sodium arsenate; the acid arsenates by using lead nitrate in place of lead acetates. The insecticidal value of the various brands depends upon the actual amount of lead arsenate which is present.

Concerning the relative value of neutral and acid arsenates no reliable experiments have demonstrated the superiority of either. It is commonly believed that the acid arsenates are more likely to burn foliage and we have received reports of injury from the use of Swift's which would seem to support the inference. Manufacturers advise using 3 pounds arsenate of lead to 50 gallons of water. We usually recommend 2 pounds, and Melander, of Washington, recommends to drench the trees with a weak solution of 1 pound to 50 gallons. Recently there has been placed upon the market a product known as zinc arsenite, which is said to be cheaper and better than arsenate of lead. Several growers have reported injury from this spray and it does not appear favorable. In the college orchard we have experimented with this spray during the past season and found it quite satisfactory.

THE SAN JOSE SCALE.

(*Aspidiotus pernicious* Comm.)

By H. F. WILSON.

It would hardly seem necessary to add to the vast amount of literature on the San Jose Scale, but with the widespread interest of city people in the orchard business we are continually called upon for bulletins on this and other well-known insects. We have little to add that is new. During the past year we have tried a number of experiments to determine whether the killing properties of lime-sulphur could be secured without the caustic and other disagreeable factors of straight lime-sulphur. Outside of lime-sulphur we have made no experiments, since this solution is entirely efficient, not only for the San Jose Scale but for certain other insects which in some stage spend the winter on fruit trees.

Since it has been shown by Dr. Schafer (5) that the principal killing agent of lime-sulphur is due to rapid oxidation, and that straight lime-sulphur is necessary, the point which we have been aiming at has apparently been settled.

A summary of our results up to date is as follows: Using lime-sulphur diluted 1 to 10 as a base, we took the separate parts and sprayed parts of trees with each.

Lime-sulphur.
Calcium polysulphide.
Calcium thiosulphate.
Calcium sulphide.
Calcium sulphate.
Calcium sulphite.
Calcium carbonate.
Hydrogen sulphide.
Sulphur.

From a practical standpoint only the first two were efficient in their killing properties. In the case of calcium thiosulphate there was an indication that it was just slightly efficient. The experiments of the first two were not satisfactory in showing comparative values between them.

Nature and Extent of Injury.

One can hardly fail to locate this insect where it is present in unchecked numbers, for the appearance of its host will be such that one who is familiar with the resulting injury can readily distinguish the more or less circular ash-gray, shield-like scales on bark, leaves or fruit. Owing to the fact that the scales closely resemble the bark of most of our fruit trees, they may be working on a tree for some time before their presence is discovered. When they are abundant, the fruit will usually be infested with few to many scales; this is the first indication that the average orchardist will notice. When allowed to develop unchecked, they soon cover branches and limbs, which, as a result of the injury, die in one or more seasons; following this, entire trees die from lack of nourishment.

It has been said that the San Jose Scale is the only scale which causes the reddening of the bark, but this is not true as the same effect is caused by other scale insects. This is quite characteristic of the San Jose Scale, however, and furnishes a fairly sure basis for identification in the orchard.

The condition of the scales can readily be ascertained by scraping them from a branch; if they are dead, the scales will rub off like a dry, gray scurf; if they are alive, the crushed bodies will produce a yellow oil-like fluid which gives the bark a greasy appearance. Wherever a scale has settled there will be a small round spot with a white speck in the middle; the spot is formed by the body of the scale while the white speck is where the long thread-like piercing apparatus, or tongue, was inserted in the bark. Oftentimes the scales will completely cover portions of limbs and overlap on each other so that they form a crust. When so badly infested, young scales will crawl under old dead

(5) Tec. Series Bull. No. 11, Michigan Agricultural College, 1911.

Plate VII

THE SAN JOSE SCALE ON PEARS.

scales and settle. We have found as many as four young scales fastened side by side under one old scale. Fruit infested with the scale becomes pitted and gnarled, as the growth is checked at the point where the scales have their beaks inserted.

"For the benefit of fruit inspectors in particular, it should be noted that reddish discolorations upon yellow fruit are not always caused by San Jose Scale. Upon yellow apples and particularly upon peaches very similar spots are produced by attacks of certain minute fungi. Hence, such spots should not in themselves be taken as proof of infestation by the scale. This can be determined definitely only by a careful examination and the actual detection of the scale. The presence of such blotches may well arouse suspicion of the presence of San Jose Scale and should challenge a careful examination alike by growers, buyers and inspector; so, also, should the presence of dead and shriveled leaves upon the trees in mid-winter invite examination, for, although their presence is not proof of the appearance of the scale, it is evidence that the vitality of the tree has been seriously impaired by some cause, and in regions where San Jose Scale is prevalent that cause, in a vast majority of instances, is the scale," (6)

Unlike most other scale insects, it develops and hatches its eggs within the body, so that the young are born alive. In May, possibly earlier under favorable conditions, the females begin to give birth to living young and may continue to produce for six weeks or longer.

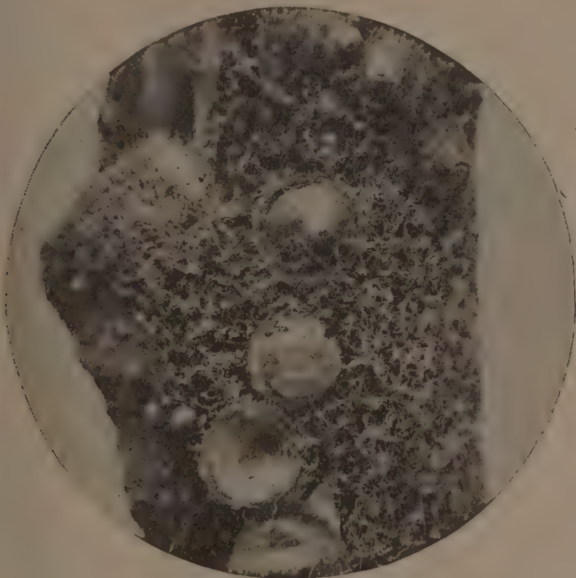

Fig. 8. San Jose Scale, Greatly enlarged.

General Description.

The young are minute, light orange yellow, active creatures with eyes, bristle-like mouth parts, two antennae or feelers, and six legs. After emerging from under the protecting scale of the parent, each wanders over the surface of bark, fruit or leaf until a suitable situation is found, when the legs and antennae are folded beneath the body, the bristle-like beak is slowly worked through the outer bark into the living tissues beneath, from which it draws its sustenance. At any time during the summer months hundreds of these little pests may be seen, even with the unaided eye, as they crawl about over

(6)A. B. Cordley, Bull. 88, Ore. Agr'l Ex. Sta., p. 6, March, 1906.

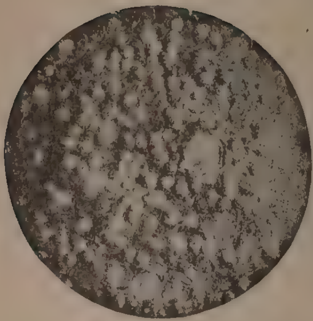

Fig. 9. San Jose Scale, slightly enlarged.

the bark or fruit of infested trees. With the first molt, all appengades, the legs, antennae, etc., except the beak, are lost.

The female scales when mature have a more or less circular scale formed of a number of concentric rings, which correspond to the various molts made during growth. Under a strong lens these appear ash-gray in color with a black protuberance or raised spot in the middle.

Remedies.

In this state lime-sulphur is generally used in combatting the San Jose Scale. The recommendations from this station have been to spray the trees while dormant either in the late fall or early spring.

"During the past four years we have conclusively demonstrated that the lime-sulphur spray. which has long been known as the most satisfactory winter spray for San Jose Scale, has fungicidal qualities nearly or quite equal to those of Bordeaux. We have also conclusively demonstrated that it may be used in combination with Arsenate of Lead without detracting from the value of either, and that when so used it is at once an efficient contact insecticide, food poison spray and fungicide." (7)

We have also demonstrated the fact that Black Leaf or "Black Leaf-40" can be combined with lime-sulphur, in control of plant lice without destroying the insecticidal value of the lime-sulphur. The most suitable time to get plant lice is in the spring, just as the buds are turning green. At that time a very large percentage of the eggs will have hatched and the young lice will not be protected by the leaves. The lime-sulphur is equally as effective in the control of the scale when applied at that time and to a slight degree may be effective against the newly hatched lice.

General Recommendations.

It is not necessary to make an application of lime-sulphur for the San Jose Scale alone. If lime-sulphur is used at any time for the control of Apple Scab or Anthracnose, the same application will suffice for the control of the scale.

In regions where neither of the above diseases exist, spray with lime-sulphur, winter strength, just as the buds are opening, and if the plant lice (any species) have been bad during past seasons, add "Black Leaf-40" at the rate of 1 part to 900 parts of the diluted lime-sulphur spray.

(7) A. B. Cordley and H. S. Jackson, Cir. Bull. No. 13, Ore. Agr'l College, 1911.

Plate VIII.

Tent Caterpillars. 1. Egg mass and nest of *M. pluvialis*. 2. Tent of *M. erosa*. 3. *M. erosa*, cluster of caterpillars on trunk of apple. 4 and 5. Larvae of *M. erosa*. 6. Cocoon of *M. erosa*. 7. Adult male and female of *M. erosa*. (Original.)

TENT CATERPILLARS.

(*Malacasoma erosa* Stretch.)
(*Malacasoma pluvialis* Dyar.)
(*Malacasoma constricta* Stretch.)

By H. F. WILSON.

Tent caterpillars, so-called because as larvae they build nests wherein they usually remain when not feeding. These nests are formed out of silken threads secreted by the larvae and serve both as a shelter and as a protection against natural enemies.

Of the many different species which exist throughout the world only three are at all serious in Oregon. To the casual observer there is little difference between the larvae and adults of these species when looked at separately. Taken side by side, however, the full grown larvae may be easily distinguished, one species from the other, and it is believed that any one can determine the species from the following descriptions.

"M. erosa. Whitish, irregular oval spots on middle of back on all but the first few segments. On either side of these spots, and somewhat separated from them is a broad blue band bordered on either side by a brick red line. Below that, on either side, and reaching to the legs is a bluish space, characterized by one blackish dot on each segment marking the position of spiracles or 'breathing holes.' Below the caterpillars are dark blue with oval black spots in median on all but first few segments. Over the whole caterpillar are numerous fine yellowish or cream colored hairs.

"M. pluvialis. The oval whitish dots of M. erosa replaced by linear blue spots on all but first few and last three segments, each bordered by black, and outside of that a mass of yellow, broken into by black spaces, each black space being marked by two blue dots. Below this on either side is a broken line of yellow, running from one end to the other, and between this and the feet a space with mottled yellow and black coloring. Below, black and irregular blotches of white on each segment. The caterpillar is covered with long deep yellow hairs coarser and more frequent than the hairs in M. erosa. On account of these yellow hairs and the preponderance of yellow in the body, this caterpillar is easily distinguished from the foregoing.

"M. constricta. A broad, broken, yellow and black line down middle of back, the line broken by constrictions, forming two irregular, quadrangular spaces on each segment. Below this on either side of the caterpillar a wide blue area containing numerous black spots which are bounded by yellow. Below, on ventral side, a nearly uniform black with indications of light spots in many of the segments. The caterpillars are sparingly covered with yellow and black hairs. This species presents a decided blue appearance." (8)

According to Prof. F. L. Washburn, a former Entomologist of the Oregon Agricultural College, of the three, *Malacasoma erosa*, *Malacosoma pluvialis*, and *Malacasoma constricta*, the first named feeds upon almost everything but the pear, viz.: apple, quince, cherry, rose, prune, etc. The second has about the same food plants as the first. The third devastates whole groves of oak, particularly *Quercus garryana*, occasionally migrating to the prune, and thereby causing considerable alarm among orchardists.

During the past two or three years *M. pluvialis* has been extremely abundant in the western part of Oregon, both on fruit and forest trees. Numerous reports have come in from about Portland and I have observed the larvae over many square miles of woodland in southern Oregon. On hillsides where alder trees constituted the main growth, the trees appeared as if a fire had swept through and scorched the leaves. On the willows and poplars found along streams in the Willamette Valley, thousands of nests were present during the season of 1912. In many cases where the foliage of a solitary willow had been devoured the nests had been formed in smaller shrubs and even on herbaceous plants.

When these larvae are very numerous they can entirely strip a tree of its foliage in a very short time. When first hatched from the eggs they are not readily noticed, but as they grow larger they are readily distinguished both by their size and by the tents which they build. These tents consist of numerous layers of closely woven silk, the threads of which are secreted from glands in the body of the insect. These various layers are probably formed by the larvae crawling over other larvae resting on top of the layers below. Toward the middle or latter part of the summer the larvae become full grown; they then seek crevices where they spin silken cocoons and change to pupae. After remaining in this stage a short time they change to the adult insects or moths which come forth and deposit the eggs. The eggs are deposited in masses on the small branches or shoots, and in the case of one species, where the eggs

(8) F. L. Washburn, Bull. 33, Ore. Exp. Sta. 1894.

are laid on new shoots, the egg mass completely surrounds the twig. These are covered with a cement-like substance which is impervious to water and climatic conditions. This gellatinous substance, besides acting as a protection to the eggs, is said to constitute the first food of the newly hatched larvae. The embryonic larvae in these eggs are nearly full fledged at the beginning of winter and usually come forth from the egg mass early in the spring. All of the moths do not emerge at the same time, so that we may find them laying their eggs until late in the fall. The eggs of the late appearing moths do not hatch until a correspondingly late period in the summer; therefore, we may find some caterpillars and nests all through the summer. This might seem to indicate that there is more than one generation a season but such is not the case. The adult moths are about one inch long and are cream colored with indistinct white bands on the wings.

Natural Enemies.—Like every other species of animal life these insects have their natural enemies, and large numbers are destroyed each season. Few birds feed upon hairy caterpillars, but according to Prof. Washburn, the Brewers' Blackbird, very common in this country, is very fond of the pupae, and may be observed tearing open the cocoons and feeding on them. They are also attacked by a fly, which lays eggs on the larvae. From these hatch minute worms which bore into the insects and feed on the tissues, thus eventually killing the host. There is a fungus disease prevalent in Oregon which is very disastrous to the insects under the right condition. This is induced by warm wet weather when the larvae shrink up and die.

Artificial Methods of Control.—In fruit orchards, spraying with arsenate of lead, as used for the Codling Moth, is usually sufficient. As the egg masses remain over the winter on the twigs the majority of the nests can be destroyed at the time of winter pruning. If these nests are not located in the winter and the caterpillars form tents in the spring, the tents can be burned out with a torch. Shade trees may be protected by spraying with arsenate of lead, 2 pounds to 50 gallons of water.

THE CHERRY AND PEAR SLUG.

(*Caliroa cerasi* Linn.)

By H. F. WILSON.

This insect is a common pest of pear, cherry, plum and other fruit trees, and although not hard to control often causes considerable damage. The name "slug" is applied on account of the slimy black exudation with which the larva surrounds itself.

It appears to be a native of Europe and was known as a pest as far back as 1740. In America the distribution seems to occur with the areas where

Fig. 10. Cherry leaves injured by slugs.

its principal host plants are found. A large number of trees, including forest and orchard trees, have been reported as attacked by this insect, but cherry, pear and plum are said to be the favorite plants.

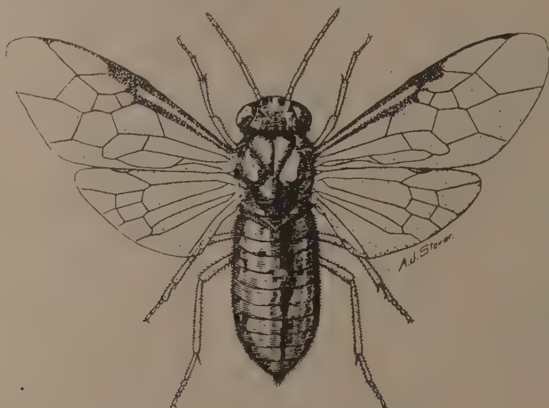

Fig. 11. Adult of Cherry and Pear Slug.

When present in any locality the larvae soon make themselves familiar to the fruit grower both by their appearance and by the injury which they do.

Most writers report them as working only on the upper surface of the leaf, while several report that they have observed them working on both the upper and lower surfaces. I have observed them working on both the upper and lower surfaces. In such instances, however, the leaves were more or less curled, so that a part of the under surface was turned upward.

In Oregon we have found but two complete broods with some indication that there may be a partial third. The first adults appear in early spring, but for some reason the eggs do not develop or are not laid until May or June; as soon as they hatch the young larvae begin feeding on the leaves and from that time until the leaves drop the slugs are present in varying numbers. Most of them, however, are found in two distinct periods: the larvae of the first generation appear more abundant during June and July; the larvae of the second generation are most numerous during August and September.

Fig. 12. Eggs of Cherry and Pear Slug.

When present in large numbers, they soon cause the leaves to become brown and the trees to look as if they had been badly scorched by fire. The adult insect is a small shining black fly with four smoky transparent wings, the smoky appearance being caused by a dusky band across the middle of the wings. On account of the saw-like ovipositor with which the insect makes incisions into the leaves, this insect and a number of closely allied species are known as saw-flies.

Life History and Habits.

Searching out a suitable place, the adult fly pushes the ovipositor rather slowly into the under surface of the leaf and makes a small oval-shaped pocket into which the egg is placed by means of the ovipositor. When the pocket is being made the tissues are so cut as to prevent their growing around the egg and destroying it or preventing the escape of the larva.

The egg is almost colorless and is flattened on the lower side. As soon as the eggs hatch the young larvae make their way to the upper surface of the leaf and begin feeding. It is claimed that the larvae eat through the tissues

of the upper surface of the leaf in escaping from the egg pocket. At first they are yellowish white in color and without slime. In a very short time, however, as the slime spreads over the body, they change to a dirty green and have more the appearance of a slug than of an insect. Immediately upon hatching they begin feeding on the upper tissue of the leaf, eating out numerous small patches, so that a number of slugs working on the same leaf will leave nothing but the dead brown skeleton of veins.

Mr. Marlatt, of the U. S. Bureau of Entomology, states that the eggs require about two weeks to hatch, and that the larvae mature in about twenty-five days after hatching.

The full grown larvae are queer looking objects, for although they each have fourteen false or prolegs besides six legs, they still appear like slugs. At that time they are dark olive green in color with the fore part of the

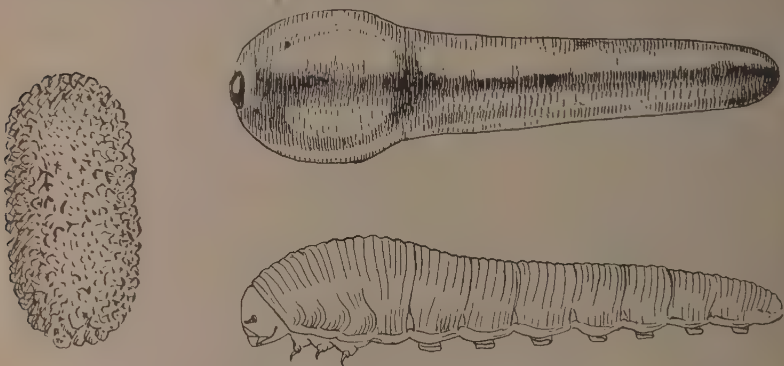

Fig. 13. Larva and cocoon of Cherry and Pear Slug.

body broad and the rear part tapering. The larvae are said to molt five times in all and after the fifth molt they do not feed any more, but crawl or drop to the ground, work their way into the soil from one to three inches and pupate. After each of the first four molts, the larvae devour the cast skins. The fifth cast skin is left on the leaf. After molting the last time, they do not again assume the the slimy protection, and instead of being green they are of a yellowish orange color with two minute black eyes. After the larvae crawl into the ground an oval cell about five-tenths inch long by three-sixteenths inch wide is made. It has been stated that this cell was made of silk and particles of dirt, but I have been unable to find any traces of silken threads and believe that saliva is the only agent used in fastening the very minute pieces of sand together.

When disturbed these cells are very easily broken apart, a fact which might indicate that fall plowing can be used as a method of destroying the pupae, according to Marlatt.

"During the heated season of July and August the transformation from the larval to the adult insect is quite rapid, the pupal stage being assumed in from six to eight days, and the adult flies transforming and digging out through the soil some twelve or fifteen days after the larva entered it." (10)

According to the studies of Peck and Marlatt some of the larvae of this spring brood remain over in the soil until the following spring. This seems to be a provision of nature to carry the species over, should anything happen to exterminate the regular line of succession, such as lack of food, unfavorable climatic conditions, etc.

Natural Enemies.

Although furnished with a sticky covering which acts as a repellant against all enemies, the insect is not entirely free from insect enemies, and in Europe

(10) C. C. Marlatt, U. S. Dept. Agrl. Bureau of Ent. Cir. 26, 2nd Ser. 1897.

some half dozen insect parasites have been reared from it. In this country a minute fly is said to sting the egg through the upper leaf tissue.

Remedies.

During the season of 1912 experimental spraying work was carried on in the college orchard to test the efficiency of different sprays, as follows:

Experiment No. 1—Sherwin Williams' Arsenite of Zinc:

1 pound to 100, 1 pound to 200, 1 pound to 300, 1 pound to 400 and 1 pound to 500 gallons of water.

Experiment No. 2—California Spray Co.'s Arsenite of Zinc:

1 pound to 100, 1 pound to 200, 1 pound to 300, 1 pound to 400 and 1 pound to 500 gallons of water.

Experiment No. 3—Swift's Arsenate of Lead, Neutral:

1 pound to 50 and 1 pound to 100 gallons of water.

Experiment No. 4—Swift's Arsenate of Lead, Acid:

1 pound to 50 and 1 pound to 100 gallons of water.

Experiment No. 5—White Hellebore:

1 pound to 50 gallons of water.

Experiment No. 6—"Black Leaf-40":

1 part to 800 parts of water.

Summary of Results.

1. Arsenite of Zinc, according to our results, cannot be used safely on cherry foliage, even at the weakest strengths which will destroy the slugs (at 1 to 500 most of the foliage dropped off in a short time).
2. Arsenate of Lead, both neutral and acid, burned the foliage to some extent, the acid worse than the neutral.
3. White Hellebore gave by far the most satisfactory results. No foliage was injured and the slugs were nearly all dead on the day following the application of spray.
4. "Black Leaf-40" gave practically the same results as White Hellebore and did not injure the foliage. "Black Leaf-40" is more expensive to use than the Hellebore.
5. Hellebore is the best remedy to use for cheapness, efficiency and lack of injury to the foliage. To get best results it must be fresh and free from adulteration.

Arsenate of Lead is cheaper but does not kill as quickly and may injure the foliage.

STRAWBERRY PESTS IN OREGON.

By A. L. LOVETT.

THE STRAWBERRY ROOT-WEEVIL.

(Otiorhynchus ovatus Linn.)

The Strawberry Root-Weevil (see Plate IX), is pre-eminently the most serious of the insect pests of the strawberry in the State of Oregon. Fortunately, it appears as yet rather restricted in its range, occurring in abundance only through the Mt. Tabor, Gresham, Oswego and Russellville districts about Portland, and in the Walla Walla Valley in the eastern part of the State. It is present also at Hood River, though not in so destructive numbers. So far we have no authentic report of its occurrence south of a line roughly estimated as running east and west through McMinnville. The first report we have on file of this insect as a strawberry pest in the State is in 1900 near Montavilla. In 1908 Prof. J. C. Bridwell, then of this department, visited the Milton-Freewater district and collected considerable valuable data concerning the pest. At present it bids fair to render the berry business unprofitable in some sections unless the growers, through a common interest, adopt more stringent methods of handling the industry.

The Strawberry Root-Weevil was undoubtedly introduced from Europe. The first report we have of it in this country is in Massachusetts in 1852. Since that time it has spread steadily westward and also northward, reaching Michigan in 1878, and being reported as a pest to the strawberry in southern Michigan in 1884. This same year, 1884, it was reported from Ottawa, Canada. It was reported from Wyoming in 1893, from New Mexico in 1894, from Minnesota in 1895, from Montana in 1897, and from Washington in 1904. When we consider the fact that this insect cannot fly, but must depend almost entirely on outside agencies for transportation, its spread seems fairly rapid. In a succeeding paragraph on the habits of the weevil this phase of the question will receive a more detailed consideration.

Common Name.

There are a variety of common names in current use for this pest. In the earlier literature of this country it received the name of graveyard bug, in some of the later literature it is referred to as the pitchy legged Otiorhynchus. Canadian entomologists refer to it as the sleepy weevil. The name commonly adopted has been the strawberry crown girdler, and here in Oregon it is termed the strawberry grub. If a common name is to be descriptive and individual, the author would suggest the name **Strawberry Root-Weevil.** In my observations, the habit of girdling the crown is rather exceptional, the majority of the grubs feeding on the small, fibrous, lateral rootlets. When they do attack the crown the habit of burrowing straight through it is just as common as that of feeding around it. So, while realizing that a mass of common names tends but to confuse, the author feels justified in adopting the name **Strawberry Root-Weevil.**

The present investigation was undertaken during the early fall of 1911. Much concerning the life history seemed yet in question and no satisfactory remedies applicable to Oregon conditions were known. The year's work has cleared up much concerning the life history and habits; the experiments thus far have been more or less in the dark and in the majority of cases the results are negative.

The fact that the pest does not occur in the vicinity of the station made it necessary to do all the field work as co-operative experiments, and it was not until late in the season that satisfactory methods for transportation to the laboratory were discovered. With other problems demanding a portion of our time it was necessary to divide our studies between this pest under field conditions and other matters here at the station. This arrangement did not afford all the opportunity for observations that might be desirable and many minor points were in consequence untouched, or not satisfactorily cleared up. Only through the obliging kindness of the growers was the work

so far conducted made possible. A host of them have aided by their interest and willingness to assist, but I desire to mention especially and to thank Mr. E. Bauman, of near Rose City Park addition, Portland; Mr. H. E. Davis, of Gresham, Oregon; Mr. H. A. Lewis, proprietor of the Russellville Nursery; and Mr. George Nagle, of Oswego, Oregon. These gentlemen have given freely of their time, hospitality and fields for my accommodation.

Destructiveness.

The Strawberry Root-Weevil is a pest both as a beetle and as a grub. The beetles feed on the foliage stripping and ragging it in a characteristic manner (see Plate IX, Fig. 4). The grubs, however, are by far the more injurious. They feed on the entire root system of the strawberry. The smaller grubs are usually found feeding on the fibrous rootlets, often devouring them entirely or barking them so that they die. A seriously infested plant may be kicked out with the foot or easily pulled up, often with the fibrous root system eaten away. Undoubtedly a portion of the grubs feed closely about the main tap root and their feeding there will sometimes girdle the crown. The larger grubs are often found buried in the tap root, and this food seems to give them a more pinkish cast, giving rise to a common belief that two species of larvae are present.

These beetles may be present in a patch for years and but little injury result from their attacks. In certain localities where I have noted their presence, the growers assure me that they have observed them for several years, yet even the older fields show no apparent injury. The common practice in the strawberry districts of Oregon is to plant in the early spring, cultivate well the first season and keep down all runners. A half crop is expected the next season and a full crop the second season or the third spring from planting. Ordinarily the fields are kept as long as profitable, and too often, in the infested districts, even longer. In the weevil districts, under normal conditions, an infested patch will show a few sickly hills the first season, small patches here and there dead the second season, and the patch rendered worthless the next spring. This affords one full crop in our system of culture. A condition that is becoming quite common, however, is for the patch to be materially weakened the first season, and the second season, or the first expected to yield a full crop, the patch is absolutely worthless. Two factors render this condition possible. The soil is often already infested with the grubs even though strawberries have not been grown on the ground previously, and again the beetles from older infested beds all about tend to concentrate on the new patch. In the various districts about Portland several types of soil are found, various cultural methods are practiced and every graduation of infestation and injury occur. In my notes concerning this phase of the subject I find the following observations:

"March 25.—Visited region about Russellville out from Portland. At place of Mr. Gill, where soil is possibly a little tight and not well stirred, there is only an occasional grub. Mr. Gill does not consider the pest especially serious. Mr. J. H. Mickelson, whose place is about three-quarters of a mile beyond, has the worst infestation I have yet seen. The plants may be easily kicked out of the soil; show but little life. The old and even the new lateral roots are eaten off right up to the crown and even the bark about the tap root is devoured. The loose, gravelly, well stirred loam is simply alive with grubs. * * *"

"May 28.—At Mr. Bauman's, near Rose City Park Addition, out of Portland * * *, a very marked difference in severity of attack, i. e., the number of beetles present is noticeable between the plants in the higher ground at each end of the patch and the plants in or near the hollow which extends through the center of the field. In the hollow nearly every plant is attacked, the number of beetles ranging from one to seven, with an average number of three to four. Only an occasional plant here free from infestation. On the hills only an occasional plant is infested and those attacked have usually one, sometimes two or three beetles. * * *"

(This observation made on a field newly set out this spring.)

"June 19.—Visited Oswego and vicinity * * * At place of Mr. Nagle find strawberry root-weevil present in goodly numbers and its injury severe. The patch was planted in the spring of 1910 and now two-thirds of plants are dead or worthless. Plants on sloping hillside show most severe attack. Plants on one side of field where soil has not been cultivated, but is in fact grassy and rather packed, are less injured than rest of field * * *"

"June 22.—* * * At Rose City Park Addition * * * in Mr. Bauman's field find plenty of beetles present. Eggs scattered promiscously through soil. * * * In the field of a Japanese, just across the fence, no trouble is experienced with this grub. It is present but makes no apparent headway in his three-year-old field. He is working the soil all the time, hoeing, scratching even during the winter. * * *"

To attempt to draw conclusions from such contradictory conditions is not easily possible.

Summed up, we have this condition: At Mr. Nagle's, Mickleson's and Bauman's, where very good ordinary cultivation is practiced, the weevil is present and is seriously injurious. At Mr. Nagle's and at Mr. Gill's, where the fields are neglected more or less, the grubs make but little headway. This is also true at the Japanese's, where extraordinary care is given.

In the Milton-Freewater district we find a distinctly different problem in many of its phases. Most of the farms through the infested district are divided into five and ten acre tracts and devoted to trees. The berries are utilized as a filler between the rows of young growing trees. Irrigation is practiced, some of the growers using water from the Hudson Bay ditch, others having private wells and pumping stations. With but few exceptions the matt system of planting is followed. The soil is fairly loose and contains considerable gravel. Practically all the fields are attacked. Those watered from the Hudson Bay ditch almost without exception show heavy infestation. There is no question but that the irrigation ditch proves a ready means of transporting the beetles. Beetles from the infested patches up stream crawl into the ditch and are washed down and carried into the fields below. I believe from my observations that where the matt system is followed the plants succumb more readily than in the hill system. This is due to the fact that the plants do not root so deeply nor make so rank a growth. Certain varieties, notably the Gibson, which is both rank of growth and deep of root, seems much more resistant to their attack than the Clark's Seedling or the Magoon.

Host Plants.

While we have so far discussed this weevil as a pest of the strawberry, it is by no means confined to this host plant. Both the larvae and the beetles have a wide and varied list of host plants to their credit and no doubt but that as our studies continue, the already complex list will be yet further extended. The raspberry, blackberry and loganberry are about all of our cultivated fruits aside from the strawberry which seem at all generally attacked in Oregon and it is not believed that the weevil will prove a serious menace to these hosts. It is very essential, however, that we know the host plant list, and for that reason we will attempt to give it in its entirety as reported up to the present time.

Host Plant List for Adult Beetles of O. ovatus.

1. Strawberry.
2. Raspberry.
3. Loganberry.
4. Blackberry.
5. Roses and other shrubbery.
6. Borage.
7. Currant.
8. Muskmelon.
9. Sorrel *(Rumex acetosella)*.
10. Wild Rose.
11. Balsam Root *(Balsamorhiza rogatata)*.
12. Potatoes.
13. Wild Buckwheat.
14. Hemlock.
15. Pumpkin.
16. Wheat.
17. Corn.
18. Cabbage.
19. Cherry.
20. Red Clover.
21. Apple (fruit).
22. Dahlias (bloom).
23. Orchid (fruit).

In Confinement.

24. Apple.
25. Cauliflower.
26. Red Clover (blossom).
27. Woodbine.
28. Tartarian honeysuckle.
29. Turnip.
30. Radish.
31. White Clover.
32. White Clover (blossom).
33. Oak.
34. Dandelion.
35. Lettuce.
36. Maple.
37. Lawn Grass.
38. Timothy grass.
40. Mulberry.
41. Spirea.
42. Rose (bloom).
43. Plantain.
44. Celery.
45. Mountain ash.
46. Roman wormwood.
47. Rhubarb.
48. Bean.
49. Nasturtium.
50. Wolf weed.
51. Night shade.
52. Box elder.
53. Thistle.
54. Cottonwood.
55. Elm.
56. Geranium.
57. Flowering currant.
58. Dahlia.
59. Syringia.
60. Peony.
61. Fall dandelion.
62. Asparagus.
63. Horseradish.
64. Chick weed.
65. Wild cherry.
66. Gooseberry.
67. Birch.
68. Iris.
69. Willow.
70. "Self Heal."

This list is compiled from the host plants as recorded at the Maine Station in an experiment conducted by Edith M. Patch. The beetles were confined for three days and the above list gives the hosts fed on to an extent at least, exclusive of those plants recorded above as natural food plants.

Host Plant List of Larvæ—Root System.

1. Strawberry.
2. Raspberry.
3. Blackberry.
4. Loganberry.
5. Wild strawberry.
6. Sorrel *(Rumex acetosella)*.
7. Grass *(Poa cerotine)*.
8. Timothy.
9. Bluegrass.
10. Potentilla glandulosa.
11. June grass.
12. White clover.
13. Hemlock.
14. Cabbage (?)

In Report of State Entomologist of New York for 1894 Prof. Lintner includes a letter from a correspondent who reports the work of the beetles on the cabbage leaf. He remarks on the subsequent decayed condition of the plant, and the presence of "* * * "little white larvae about one-third of an inch long which destroy the centre of the stalk and leave it a foul smelling, jelly-like mass." It is quiet possible the correspondent had really found maggots of some diptera, attracted there by the decay.

Description.

The Adult Weevil is a snout beetle, 6 mm., or nearly one-fourth of an inch in length. The color of the insect varies from a dull reddish brown when freshly emerged to almost pitch black; the surface is roughly pitted and slightly shiny. The beak is short, broad and emarginate at the tip; there is a distinct puncture between the eyes. The antennae are elbowed and consist of nine segments. The proximal segment is set in a pit; it is elongate, finely haired with light yellow fluff, slightly curved and enlarged toward distal end to form the socket of the elbow joint. The next seven segments are bead-like with coarse dark hair. The distal segment forms an ovate knob and is finely haired the same as the proximal segment. The thorax is nearly globular, tuberculate, pitted and coarsely grooved. Each tubercle bears a short hair. The body behind the thorax is oval, the striae more uniform. There is a distinct narrow, dark, shining ring between the thorax and body proper. The femur of each leg bears a spur. The beetle is without wings, but with elytra very hard and securely grown together. Upon removing the elytra, rudimentary wing pads are found still present.

"June 22.—* * * At Rose City Park Addition * * * in Mr. Bauman's field find plenty of beetles present. Eggs scattered promiscously through soil. * * * In the field of a Japanese, just across the fence, no trouble is experienced with this grub. It is present but makes no apparent headway in his three-year-old field. He is working the soil all the time, hoeing, scratching even during the winter. * * *"

To attempt to draw conclusions from such contradictory conditions is not easily possible.

Summed up, we have this condition: At Mr. Nagle's, Mickleson's and Bauman's, where very good ordinary cultivation is practiced, the weevil is present and is seriously injurious. At Mr. Nagle's and at Mr. Gill's, where the fields are neglected more or less, the grubs make but little headway. This is also true at the Japanese's, where extraordinary care is given.

In the Milton-Freewater district we find a distinctly different problem in many of its phases. Most of the farms through the infested district are divided into five and ten acre tracts and devoted to trees. The berries are utilized as a filler between the rows of young growing trees. Irrigation is practiced, some of the growers using water from the Hudson Bay ditch, others having private wells and pumping stations. With but few exceptions the matt system of planting is followed. The soil is fairly loose and contains considerable gravel. Practically all the fields are attacked. Those watered from the Hudson Bay ditch almost without exception show heavy infestation. There is no question but that the irrigation ditch proves a ready means of transporting the beetles. Beetles from the infested patches up stream crawl into the ditch and are washed down and carried into the fields below. I believe from my observations that where the matt system is followed the plants succumb more readily than in the hill system. This is due to the fact that the plants do not root so deeply nor make so rank a growth. Certain varieties, notably the Gibson, which is both rank of growth and deep of root, seems much more resistant to their attack than the Clark's Seedling or the Magoon.

Host Plants.

While we have so far discussed this weevil as a pest of the strawberry, it is by no means confined to this host plant. Both the larvae and the beetles have a wide and varied list of host plants to their credit and no doubt but that as our studies continue, the already complex list will be yet further extended. The raspberry, blackberry and loganberry are about all of our cultivated fruits aside from the strawberry which seem at all generally attacked in Oregon and it is not believed that the weevil will prove a serious menace to these hosts. It is very essential, however, that we know the host plant list, and for that reason we will attempt to give it in its entirety as reported up to the present time.

Host Plant List for Adult Beetles of O. ovatus.

1. Strawberry.
2. Raspberry.
3. Loganberry.
4. Blackberry.
5. Roses and other shrubbery.
6. Borage.
7. Currant.
8. Muskmelon.
9. Sorrel *(Rumex acetosella)*.
10. Wild Rose.
11. Balsam Root *(Balsamorhiza rogatata)*.
12. Potatoes.
13. Wild Buckwheat.
14. Hemlock.
15. Pumpkin.
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The Egg is about .55 mm. in length and about .29 mm. in width. It is milky white with pronounced translucence when first deposited, later changing to a dirty yellowish brown. It is smooth when first deposited but indentations soon appear and by the time it has assumed the darker color it is decidedly roughened.

Larva—The length of the larva at the time of hatching is .75 mm., the breadth of the head during the first instar .24 mm.

Weed (10) describes the larva and pupa as follows:

"**Larva.**—All of the larvae which were seen eating were of a pinkish tinge, but when compelled to fast became white. The full grown larva is three-eights of an inch long by one-eighth of on inch wide; white, except the head, which is light brown, with the mouth parts darker and the edges of the jaws black. The head is smooth except for four transverse rows of light brown hairs. The body is arched; on each segment is a row of reddish brown hairs, curved at the tip on the back, but shorter and not curved on the under side. The dorsum or upper part of each ring is divided into three transverse lobes or folds, all except the first and the next to the last of which are smooth. On the under side of the first three segments are tubercles in place of feet; these possess stiff hairs. On the sides of each segment are two triangular tubercles, each bearing two hairs, one of which is but half as long as the other. A longitudinal fissure separates the upper row of tubercles from the lower.

"**Pupa.**—When first transformed the pupa is pure white, three-eights of an inch long by two-eighths of an inch wide. The head and snout are bent against the breast, the latter not quite twice as long as wide, tapering slightly towards the tip, the jaws plainly visible. The elbowed antennae extend to the base of the wing cases; the abdomen terminates with a pair of incurved hooks. On each segment of the head and thorax is a transverse row of spinous reddish brown hairs terminating by recurved hooks. On the outer end of each femur (thigh) is a pair of similar spines, the inner but half as long as the outer. On each segment of the abdomen is a transverse row of reddish brown awl-shaped bristles.

"A day or two after transforming the black eyes show through the pupal envelope at the base of the snout, and in a few days more the mouth parts and the legs become brown. In about eight days the wing cases develop, and the body becomes light brown, which in a day or two changes to dark brown."

Seasonal History.

The Strawberry Root-Weevil is single brooded. The adult beetles may remain alive and active for more than a year. There are then for a short period of time two generations of beetles present. This complicates matters somewhat and affords a reasonable chance for error in checking up the life history. These beetles are busily engaged feeding on the foliage of the strawberry and other hosts, ragging and stripping it. The insects pass the winter in both the adult and grub stage. The beetles hibernate in all conceivable sorts of places. Many of them become restless in early September and begin seeking a place for hibernation. Very often in this search they enter dwellings and prove a source of no little worry to the housewife by crawling over and under everything and dropping from the walls and ceiling into dishes and vessels not intended for their occupancy. Many of them remain in the field, hibernating in the soil up close about the crown of their host, or crowded down into the sheaths about the central whorl of the crown. They also hibernate under heaps of leaves and debris about the field, in fence corners, under boards and loose bark. They have been found in bundles of shingles, in bundles of bedding and in crates of nursery stock and other transportable material. This may account in a large measure for their spread to new localities. The grubs pass the winter in the soil about the roots of their hosts. A portion of them are mature in late fall and even form in the soil what will constitute the pupal cell. The majority of the grubs pass the winter as nearly mature larvae, feeding to a limited extent on their host. A very few grubs occur during the winter as only half-grown larvae, and these naturally prolong the period of pupation and emergence of the adult weevils the following spring. The first pupae occur in early May. Our earliest observation of a newly emerged weevil is May 21. In the single instance where I successfully reared a beetle from the larva, the pupal stage was eight days. During late May and June the majority of the new generation of beetles emerge. Even earlier than this the overwintering brood of beetles assume a traveling habit and crawl for a considerable distance. The new generation of beetles also travel, and during May the housewife is again worried by the presence of this beetle in the house. About two weeks after the new generation of beetles commence

(10) Weed, C. M., Mich. Hort. Soc. Rept., 1884, p. 85.

to emerge the first eggs are found. The majority of these eggs are deposited promiscuously through the soil from one-half to three inches below the surface and extending from close about the crown out in a radius as great as that covered by the foliage of the plant. Later in the season as the soil dries out, eggs are deposited about the central growing whorl of the crown, usually well down among the sheaths. They are also found in cracks and crevices frequented by the beetles and in the tunnels that sometimes occur about the base of the plants. These tunnels are mentioned by Cooley (11) as formed by the beetles, but it is my belief that they are formed by earth worms and are simply appropriated by the beetles. The largest number of eggs deposited by a female in confinement was 43. In dissections, eggs were found in numbers from 23 to 67, with an average of 42. It is believed that the average egg production is higher than this, however, as in the dissections many immature ovae were found, and the egg period in the field extends over a period of several weeks. The beetles themselves feed at night and during the day crowd down in dark sheltered places. They will often be found in numbers under a clod, in a crevice or crack in the soil, in these tunnels mentioned above, or crowded down about the crown of the plant itself.

The eggs begin hatching in about nine days; in our observations the incubation period was from nine to 24 days, with an average of about 14 days. The egg is comparatively hardy, will stand considerable handling and jostling about, and unlike the egg of many insects, will hatch even in dry soil. The egg-laying period extends apparently well into the season, at least until July 20. By far the majority of the eggs are deposited, however, during June. The young grubs are fairly hardy and active. They can live in dry soil for 36 hours without food and can travel over loose dry soil at the rate of eight inches in 16 hours.

It is very doubtful if the overwintering adults deposit eggs in the spring. A dissection of nearly a hundred individual beetles during late April failed to reveal a single forming ovum.

Control Measures.

Preventive Measures—As stated earlier in this paper, the experimental work we have undertaken so far toward combatting this pest is strictly preliminary, and what meager results have been obtained must necessarily be considered merely tentative.

Barrier Method—Taking into account the inability of the beetles to fly we conceived the idea of a barrier about the newly set fields to keep them out.

On March 25, at the place of Mr. Bauman, near Portland, the proposed plat was examined carefully for O. ovatus. A very few beetles were found about the base of the sorrel, a prevalent weed in the cultivated soil of this district. As Mr. Bauman plowed the field we looked carefully for grubs in the soil. Only rarely was one found. This field had been planted to potatoes the previous season. It had been designed for use later as a strawberry field, hence special care was taken during the spring and early summer to keep all wild vegetation down. The field which is about one and one-half acres in area, is very irregular in contour, a hollow cutting diagonally through it near the center.

The strawberry plants were set in the field on March 26 and 27. The barrier was started eight days later and required three and one-half days for completion. The completed barrier consists of 12-inch boards placed on edge about the field, well braced from the inside, all the joints carefull fitted and insect proof. Along the top edge of the fence is a tin strip projecting out over the edge of the board about one and one-half inches. The earth is mounded up about three inches against the base of the barrier on the outside. Soon after the barrier was completed a narrow band of crude oil was placed about it on the outside, just below the projecting strip of tin.

One factor not given sufficient thought in our project was the very early

(11) Cooley, R. A., Mont. Exp. Sta. Bull. 55, p. 136.

emergence and migration of these overwintering beetles. In the interval between the setting of the strawberry plants and the completion of the barrier, the weather continued warm and sunny. During the night time the beetles proceeded to crawl everywhere and in this way infested the newly-set field. A careful examination on April 22 showed an average infestation of about one beetle per hill. In the hollow as many as three to five were collected about nearly every plant while on the higher ground only an occasional beetle was to be found. Crowded up about the base of the barrier on the outside were large numbers of these beetles, unable to gain access to the field. An examination at 9:15 p. m. revealed a few beetles up on the tin at the top of the barrier. Some of these individuals had crawled through the crude oil from the outside.

On April 25 the field inside the barrier was sprayed with an arsenical spray prepared according to the following formula:

Lead Arsenate Paste	3 pounds.
Whale Oil Soap	3 pounds.
Water	50 gallons.

The whale oil soap was added to aid the solution in adhering to the foliage. The material made in this manner requires more time in the preparation, but it certainly causes the solution to stick better. Frequent examinations showed that the material formed a smooth even coating over the rather slick strawberry foliage and even on the hairy stems. Incidentally, the material so prepared remains in suspension much better.

An examination at intervals, both day and night for three days following the application of the spray, failed to show any signs of the beetles having fed on the sprayed foliage. The spray was not conspicuous on the foliage, but a careful examination showed a thin even coating of the arsenical over the whole upper leaf surface.

Observations at various times during the spring and summer showed that beetles continued, to a limited extent, to gain access to the field. Some of the beetles of the new generation gained entrance during late May and June and eggs were found about the base of the plants at this time.

This experiment is not yet closed. Another season's observations may change the value of our conclusions considerably. Briefly summarized to date we have the following:

I. The cost of the materials for constructing this barrier about one and one-half acres was $26.67. Three days were taken for actual construction.

II. The above estimate does not include the tangle foot or crude oil about the barrier. With crude oil frequent renewals are necessary. Tangle foot would remain in condition longer but is more expensive.

III. The vegetation must be kept down about the barrier or beetles will crawl over by this means.

IV. Only under certain conditions could this barrier prove practical at all. It would be of no avail to the orchard man, for instance, who uses the strawberries as a filler between the rows of trees. On soil already heavily infested with the grub, the barrier would prove of little avail.

V. By a little change in this season's operations the beetles may be kept from entering the field in injurious numbers. Another season the tin will be discarded thus doing away with this item of expense. Tangle foot or oil of resin will be used instead of crude oil; some provision will be made for gaining access to the field with a team if it is desired to cultivate and spray. The barrier should be in place by March 20.

One Crop Rotation.—Prof. James Fletcher (12), late entomologist of Canada, recommends what he terms the one crop plan.

"This consists of setting out new beds of strawberries in the spring, cultivating these for the first summer, taking one large crop of berries the next spring, and then ploughing the plants up as soon as the crop is off. In the meantime a new bed will have been set out from the runners of the bearing bed early in the spring before the fruit ripened. This plan of strawberry culture not only prevents loss from the attacks of such enemies as the White Grubs and the above mentioned Weevils" (*O. ovatus O. sulcatus*), "but is also a paying operation, giving better returns from the higher price secured with the large fruit thus grown than from a large crop of small berries."

(12) Fletcher, James, Can. Exp. Farms Rept., 1904, p. 242.

Trapping.—The insects feed at night and tend to seek shelter in darkned, cool places through the day. Various traps may be used to attract them. 'rof. Fletcher (13) recommends common flower pots filled with hay, inverted nd raised slightly from the ground. If these are placed about the field the eetles will crawl inside for protection and may be shaken out into a bucket f water having a thin surface-coating of oil.

Irrigation Ditches are a means of distribution, as I mentioned earlier 1 my report of the Milton-Freewater district. Where a company ditch is sed by a community, beetles from an infested patch up stream will crawl ıto the ditch and be washed down and into new fields below. To avoid this ıeans of infestation the use of private wells and a pumping station seems the nly solution and this is not always possible or practical.

New Plants should be obtained, so far as possible, from uninfested disricts. When obtained from a suspicious neighborhood the plants and conainers should be examined carefully for adult beetles.

Remedial Measures.

An ideal substance for the control of this pest would be one which had he property of killing the grubs in the soil, repelling the beetles from the lants and still not injuring the plants themselves. Carbon-bi-sulfid injected ıto the soil has been tried by some of our correspondents who report the reatment slow, expensive, sure death to the grubs if applied just right, but ıjurious to the plants if applied too close. The consensus of opinion was to he effect that the use of carbon-bi-sulfid was impractical.

It seemed possible that if one might find an oil having the ability to olatilize slowly, and with more or less odor, the gases arising in the volatiliation of the oil might kill the grubs and the odor tend to repel the adult beetles. /ith this explanation of the object I had in view, I shall not go into the disussion of the various steps more than to say that cheapness as well as efficiency 'as taken into account.

In working up these materials, I designate the proportions of the liquid ɔ each other. The powder simply gives body to the material and was added 1 such quantities as needed and stirred or worked into the material until it ssumes the desired consistency. The finished product was a moist, gritty owder, not unpleasant to handle.

The Maine Station recommended a powder for the destruction of chicken ce. This was the first material prepared using the same materials in the ame proportion. These are designated as I and II.

No. I. Crude carbolic acid one part, gasoline three parts, plaster paris ɔ form powder.

No. II. Kresol one part, gasoline three parts, plaster paris to form owder.

No. III. "Carbolineum" (a commercial solution with crude oil as a ase, recommended as a tree wash), and plaster paris to form powder.

No. IV. Crude carbolic acid one part, gasoline three parts, sulphur to ɔrm powder.

No. V. "Carbolineum," sulphur to form powder.

No. VI. Black Leaf (old form), sulphur to form powder.

No. VII. Crude Carbolic acid one part, gasoline three parts, sulphur ɔ form powder and salt about one part to 200 parts of powder.

No. VIII. Crude carbolic acid one part, gasoline three parts, air-slaked me to form powder.

No. IX. Black Leaf (old form), air-slaked lime to form powder.

No. X. Tobacco dust.

No. XI. Air-slaked lime.

No. XII. Sherwin Williams "Soil Insecticide."

No. XIII. "Naptho Nicotyl," an English soil insecticide.

April 19, at place of Mr. H. E. Davis, at Gresham, Oregon, set experi-

(13) Fletcher, James, Can. Exp. Farms Rept., 1905, p. 186.

mental field as follows: The new plants for my plat were dug from an old infested patch and were set out on either side of the infested patch.

Materials number V, VI, VII and XII were used. A couple of tablespoonfuls of material were placed in the small excavations prepared for the plants and stirred into the soil about the roots as the plants were set. Check rows were planted.

April 23. At place of Mr. Lewis, at Russellville, set experimental patch as follows: The field used had been in ornamental stock and holly for a year or more and was well sodded. There were no infested strawberry fields adjacent to this plat, though the older fields some little distance away (half mile), were infested. The plants used were dried out considerably, having laid about in sacks for a time. They were set in the same manner as at Gresham, a slight excavation being made with a trowel, where the plant was to stand and some of the material worked into the soil.

Materials number I, II, V, VI, VII, X, XII, XIII were used. Also treated some plants as follows:

XIV. Lead arsenate solution, 50 plants submerged.

XV. Lead arsenate solution, 50 plants tops dipped.

Checks were maintained at various places in the field.

May 29. At place of Mr. E. Bauman, I treated plants already set in field. There were a small number of the adult beetles already present about them. The following materials were used: Numbers VIII, IX and XI. The material was simply dropped in small heaps on the crown of the plant and allowed to filter through to the soil down about the base.

Report on Results of Treatment.

No. 1. Nearly all treated plants are dead, the rest badly set back and feeble.

No. II.. All plants dead.

No. V. Plants dead or showing only feeble signs of life.

No. VI. Plants backward, but doing nicely, no beetles yet present, May 27.

No. VII. Plants all dead or dying.

No. VIII. This material was used only on plants already established. Burned foliage slightly, did not keep beetles away for any length of time.

No. IX. Used at same time as VIII, no injury to plants, did not keep beetles away for any length of time.

No. X. Plants a little backward, but later doing fine, no infestation.

No. XI. Plants appear extra well in size and color. A few beetles. (Used at same time as VIII and IX.)

No. XII. Plants dead or seriously injured, no beetles near.

No. XIII. Plants all dead.

No. XIV. Plants backward but alive and growing.

No. XV. Plants slightly backward but alive and growing well.

Checks in all cases are doing well and were used as basis of comparison.

Conclusions.—The materials almost without exception were used entirely too strong. The odors and gases in these materials are retained for so short a time as to be of no practical value. Negative results seem rather the rule; most of the materials, however, will be tested another season. Air-slaked lime and salt, applied in combination and separately, tobacco dust and salt, and the arsenical dips, are the ones which will be tested exhaustively, as they give more promise of having insecticidal value.

Arsenical Sprays.—In a series of laboratory tests where adult beetles were confined with sprayed foliage we found that in the few cases where the weevils fed they were killed, but only occasionally did they feed on the sprayed foliage, even when starved for some time previous. This corresponds very well with the results of Prof. Cooley (14). He found that under field conditions where the foliage was sprayed the weevils would attack the crown of the plant. The feeding of the adult beetle amounts to but little here; hence the chief value of the spray would be in its ability to repel the beetle or make the plants uninviting.

(14) Cooley, R. A., Mont. Agr'l Exp. Sta. Bull. 55, p. 141.

Ashes and Lime scattered over the field, the field then flooded with vater, is recommended by one grower, who claims he keeps his field free vhere his neighbors suffer greatly. I have made no careful investigation of this treatment.

Flooding the soil for a period of several weeks during the dormant season vill be tried by one of the growers in the irrigated section this fall. Just what he effect will be on the berry plants and young trees only time will deter- nine.

Natural Enemies.

The natural enemies have not been given the study they should. An mmature Gamasid mite was discovered feeding on the eggs at Gresham, Oregon.

Domestic fowls feed on the larvae and pupae when allowed to follow the low.

Carabid beetles and their larvae are often found about the hills.

At least two species of spiders attack the adult beetles. Unfortunately he material collected for determination of the species was lost. These spiders onstruct their webs in the foliage of the strawberry plant. The remains of s high as 18 adult weevils were found in a single web.

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Allied Species of Weevils Found on Strawberry.

Several very closely allied weevils have been found infesting the straw- erry in the state of Oregon. *Otiorhynchus sulcatus* occurs in the vicinity of Portland and also in the Milton-Freewater district. In these two localities larger species also occurs (Plate IX, Fig. 9), which in the Milton-Freewater listrict is doing considerable damage in a few of the strawberry fields. In he vicinity of Oswego a third species, *Otiorhynchus rugifrons* (see Plate IX, Fig. 8), bids fair to outclass the *Otiorhynchus ovatus* in its ability to multiply nd to destroy berry fields.

Otiorhynchus sulcatus is not considered of especial importance by the rowers. It apparently does not spread rapidly nor multiply fast enough to njure a field to a noticeable extent. The larger weevil has a variety of host lants. It is capable of injuring a strawberry patch by the third season or he fourth spring from planting. Adults, pupae and grubs of this species were ound in the same fields with *Otiorhynchus ovatus* at Milton. *Otiorhynchus ugifrons* was found nowhere but in the vicinity of Oswego. There many of he growers have given up strawberry culture entirely and others report most iscouraging prospects where this pest is present. In a great many cases the ields were so severely injured the second season that a full crop was not realized. This beetle is slightly larger than *ovatus*, more prolific and may prove a worse trawberry pest than its dreaded ally. No especial study of these species has o far been made in Oregon. It would seem that the same remedial measures vould apply as for *ovatus*.

STRAWBERRY CROWN MINER.

(Aristotellia sp.)

Fig. 14. *(Aristotellia sp.)* Strawberry crown showing the burrows of the crown miner. Also a mature larva in its cocoon in the crown. (Original).

This strawberry crown miner is present in the state of Oregon about everywhere that the strawberry is grown. In many localities fields have been observed which were severely injured and an examination showed this pest to be wholly responsible for the trouble.

While the names of these various insects infesting the strawberry roots may at first appear confusing, a glance at (Fig. 14) will aid in distinguishing the work of this pest. The larvae are not grub like, but are longer, more slender, of a distinct reddish color and with a brown head. When mature they are less than half an inch in length. They feed almost entirely within the crown, usually mining just within the bark, constructing long tunnels either up and down or around the crown. Others tunnel directly through the crown or else up and down the cork-like interior of the root. Still other larvae are found

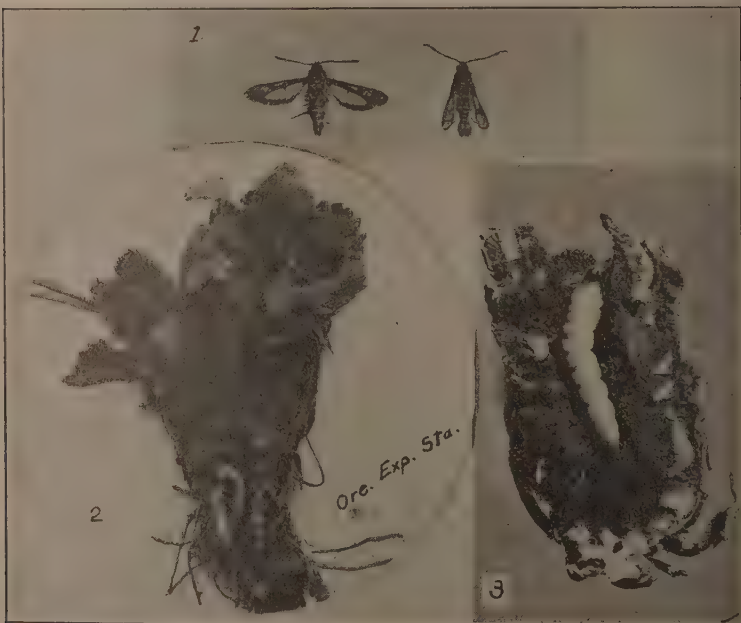

Fig. 15. Strawberry Root Borer *(Sesia rutilans)*. 1, adult moths; 2, strawberry plant showing larva; 3, larva in its burrow in the root. (Original.)

feeding in the whorl of leaves at the growing tip of the crown and a few have been observed mining in the petiole of the leaves.

The adult of this crown miner is a small moth, resembling very closely in general appearance the peach twig miner, *Anarsia lineatella*. It is a weak flier and very sluggish in its movements. The eggs are deposited on the sheaths about the crown, on the underside of the leaves, and along the leaf petioles. They are usually pushed well down among the fine hairs. The egg is white with a dull lustre, a slight area at the smaller end being transparent. The surface of the egg is ribbed and pitted, very much resembling the hull of a peanut. The egg is elongate, flattened at the larger end, the edges rounded. From the base end it gradually increases in size to near the middle, then slopes down to a blunt rounded point. It measures .55 mm. long and .29 mm. wide.

Remedial Measures.

Plowing up the infested plants is the method of treatment recommended.

It would seem that possibly the young larvae on hatching from the egg might feed on the leaf or petiole before entering the crown and could be successfully poisioned with an arsenical spray.

THE STRAWBERRY-ROOT BORER.

(Sesia rutilans Hy. Edw.)

This root borer is a serious pest of the strawberry, occurring in the state of Oregon nearly everywhere the strawberry is grown. The elongate, white larva, with brown head and darker biting jaws, feeds on the interior of the crown and tap root of the strawberry plant, eating out the entire heart. The plant, as a result, looks sickly, and when pulled up will often break just below the crown, exposing the tunnel filled with frass and excrement and often the larva itself. The adult insects are clear winged moths (see Fig. 15.)

Remedial Measures.

Dig up and destroy infested plants, preferably in late fall or early spring.

Plate IX.

Otiorhynchus ovatus. 1. Eggs, adult, pupa and larva. 2. Plant showing root injury. 3. Adults, *O. ovatus*. 4. Leaves showing feeding punctures of adults. 5. Pupal cell in soil. 6. Infested strawberry field. 7. Corner of barrier used in experiment. 8. Adults, *Otiorhynchus rugifrons*. 9. Adult, pupa and larva of large weevil found at Milton, Oregon. (Original. Insects natural size.)

THE CURRANT MAGGOT OR GOOSEBERRY FRUIT FLY.

(Epochra canadensis Loew.)

By A. L. LOVETT.

This insect is possibly as serious a pest of the currant and gooseberry fruits as we have in the state. The attack is on the fruit itself and causes it to become prematurely ripened and altogether worthless. The first indication of injury due to this insect is a small spot on one side of the fruit where growth has apparently ceased. Later the fruit shows a cloudy appearance, becomes prematurely ripe and upon examination reveals a dark spot in the interior, which proves, when the fruit is opened, to be a small footless grub. The fruit drops to the ground, and as a result, the crop is shortened greatly or is entirely ruined.

The adult of this maggot is a very pretty two-winged fly about the size of a house fly. It is of a pale yellow or orange color. The wings are marked with dusky bands. The grub or maggot is footless, white in color and with the body composed of 13 segments. The head is armed with a pair of black, parallel, retractile hooks, the rasping organs of the maggot.

Life History.

The adult flies emerge during May and may be observed about the bushes during late May and June. Soon after emergence the females commence depositing eggs. One female may lay as many as 200 eggs; usually she will deposit but a single egg in a fruit. The egg-laying process is interesting; the fly alights on the fruit and hurries about in a nervous manner, keeping the wings in constant fanning motion. When at last suited with the location she pierces the fruit with her ovipositor and pushes the egg under the edge of the skin. The egg hatches into a small white grub, which at once commences to feed and travel. Its route may be readily traced just under the skin by the discolored path of injured cells and excrement left behind. After traversing a greater or less distance around the fruit, the maggot turns to the interior and enters one of the seeds. After growing too large to remain in a seed, it binds several seeds together and continues to feed on their contents. Occasionally the larvae leave the fruit before it drops to the ground. More often they remain in the fruit until after it has fallen, where they complete their growth, and when ready to transform to a pupa crawl out of the fruit and into the soil. They enter the soil to a depth of about one and one-half inches, where they form an earthen cell and transform to a pupa. They remain in the soil as a pupa until the following May when they emerge as adult flies.

Control Measures.

This insect is not an easy one to control. The fact that the egg is deposited under the skin of the fruit and that the larva spends its entire existence in the interior, makes poison sprays for the larva of no avail.

Sweeping.—An insect net swept over the vines in the early forenoon during June should collect many of the flies. They could then be dipped in hot water or suds.

Poultry.—Young poultry allowed to run in the patch a few hours each day will pick up the fallen fruit containing the maggots and materially lessen next season's crop of flies.

Spading.—Advantage may be taken of the fact that the pest spends nearly 11 months in the soil. Spade up the soil thoroughly to a depth of four or five inches close up about the bushes. This will break up the pupal cells and expose the insect to unfavorable weather conditions and the attack of its enemies.

Mulching.—Mulching heavily with straw in the spring might prevent the flies from emerging as they are very weak when newly emerged.

Spraying.—In a series of experiments with the Mediterranean Fruit Fly, an insect similar to this in many respects, Professor Malley, of Cape Colony, had very good results following the application of a sweetened poison spray.

Thinking it might be possible to attract the adult flies of the currant maggot in a similar manner, we proceeded as follows:

The Malley sweetened poison:

Sugar	3 pounds.
Lead arsenate	4 ounces.
Water	5 gallons.

Field tests of this spray were made at the following places:

April 22.—Mr. Theo. Brugger, Gresham, Oregon.
April 29.—Mr. Mickelson, Russellville, Oregon.
May 8.—The college field.
May 14.—The college field.

The material was applied as a coarse spray with a small compressed air hand pump. The object in mind was to have the solution form as large globules on the upper surface of the leaves. No especial pains were taken to avoid striking the fruit with the spray.

No conclusive results were obtained, but the following brief summary of the season's trials is possible:

1. The sweetened poison does attract the fly, *Epochra canadensis*.
2. Our frequent rains during this period make frequent applications necessary.
3. Granulated sugar is rather expensive; it crystallizes quickly and is not so satisfactory as a cheaper brown sugar would probably be.
4. The crop was injured one half in many localities and in a few cases the fruit, due to the maggot's attack, was not worth gathering. Infested fruit does not always drop; often it remains on the bush and does not color prematurely. It can only be detected when it is broken into.
5. It is not considered that the amount of poison which would incidentally fall on the fruit is sufficient to endanger human life. The foliage spray is more effective for the flies.

Some Facts which will be borne in mind another season: Prof. Malley recommends a light sprinkling of fine spray, letting it fall as minute globules on the leaf surface. He finds that in the case of the large globules the poison settles out and collects in a concentrated form at the bottom of the globule. This makes it possible for a fly to feed without obtaining poison at all.

He had equally good results with treacle and with cheap brown sugar. These materials will not crystalize as does granulated sugar, and he found that the flies would feed upon the material even after most of the water has evaporated.

Do Not in any case use honey as the sweeting agent to attract the flies, as this will also attract honey bees.

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THE RASPBERRY CANE MAGGOT.

(Phorbia rubivora Coq.)

The new canes of the raspberry, loganberry, dewberry and blackberry are sometimes observed in the spring drooping in a characteristic manner. If the affected shoot is examined carefully, a bluish ring will be observed at the base of the wilted tip, and by cutting into the interior a small, whitish maggot is disclosed.

The adult of this maggot is a fly, similar in appearance to the house fly, though somewhat smaller in size. These flies appear in early April and are present through May and June. The females deposit eggs on the canes of their host. The egg is usually placed in the groove formed by the branching off of the leaf axil from the growing stem. The egg is white in color, elongated and of a fair size. The maggot which hatches from this egg crawls down the

cane a short distance and bores its way through the surface of the stem and into the pith. The maggot feeds down the cane for a short distance, it then turns toward the surface or bores through the woody tissue to just beneath the surface of the bark. It now turns at right angles and girdles the cane. This girdle constitutes the bluish ring, from the effects of which the tip wilts and dies.

Remedial Measures.

Cut off the infested canes well below the girdle and destroy.

LEAFHOPPERS OF BLACKBERRY AND LOGANBERRY.

The leafhoppers are very small insects belonging to the order Hemiptera, or true bugs. They have the characteristic piercing or sucking mouth-parts of this order, and have, in the adult state, wings with which they fly quickly, when approached. Where they occur in numbers their presence is usually noted because of their habit of rising in small, quickly disappearing clouds ahead of one as he walks through the field.

Nature and Extent of Injury.

The injury to Loganberries and blackberries due to leafhoppers is seldom noticed unless severe. Often the injury they cause is charged to other agencies, such as fungus, drouth or frost and their ranking as a pest is certainly under-estimated. The foliage first appears speckled, white spots occuring on the upper surface of the leaves. Later the foliage becomes a sickly yellow with spots of white and dark green all over the surface. An examination of the under surface of the leaves at this time reveals the cast skins and a few adult forms. In addition to the injury to the foliage, the hoppers often attack the developing flower buds. A bud or flower pierced by the leafhoppers will not develop normally nor produce a perfect fruit.

Control Measures.

Preventive:—Clean up all leaves and trash in and about the field. Burn any grass in adjacent fence corners and fields where possible. Plow in the spring where practical.

Remedial:—Remedial measures to prove most effective must be practiced in the early season on the nymphal forms. At this time the hoppers occur principally on the lower leaves, and by using an underspray nozzle and maintaining a fairly high pressure almost any of the contract sprays will control the pest. It must be born in mind that the spray must actually wet the insect to prove effective. The adult insects and eggs are not usually killed by the spray and a second or even a third application may be necessary.

Among the contract sprays which are recommended are the following:

Whale oil soap, one pound to 10 gallons of soft water.

Kerosene emulsion, if properly prepared, is possibly the best spray for the leafhopper. It should be used as a 10% solution.

Resin spray composed of one pound of resin and one-quarter pound of lye dissolved in 15 gallons of water.

The tobacco sprays are also effective. "Black Leaf-40" at the rate of one-half pint of "Black Leaf-40" and two pounds of whale oil soap to 50 gallons of water makes a very efficient contact spray.

For the adult leafhoppers one might use sticky shields, something as recommended for the grape leafhopper. These shields consist of heavy wires slightly curved and about 5 feet in length, the completed shield being about 4 feet wide. The wires are covered with oil cloth or canvas and the cloth smeared with crude oil or oil of resin. If two men each carrying one of these shields pass down opposite sides of the row at the same time, many of the hoppers will fly against the sticky surface and lodge.

THE CABBAGE AND RADISH MAGGOT.

(Phorbia brassicae Bauché.)

By A. L. Lovett.

This insect is considered a very serious pest throughout the state of Oregon, or wherever cabbages and radishes are grown. In the truck crop regions, where these crops are grown over considerable areas and for a period of years on the same soil, the pest is especially serious.

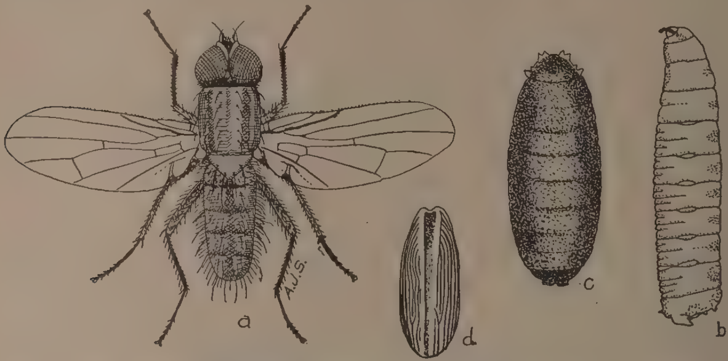

Fig. 16. The Cabbage Maggot *(Phorbia brassicae)*. a, adult fly; b, the maggot; c, puparium; d, the egg (much enlarged). (Original.)

Its Occurrence.—Just when this pest first made its appearance in Oregon is uncertain, but as early as 1891 F. L. Washburn, the entomologist of this station, in reporting on the injurious insects of the year, refers to it as "unpleasantly common."

Plants Attacked.—Besides attacking the cabbage and radish, this maggot feeds on the turnip, cauliflower, celery, rape, kale, and a variety of the closely allied Cruciferiae. It is also found about the roots of some of the wild plants of this group, including mustard and radish.

Description.

The Larva.—It is as a larva that the cabbage maggot is injurious and hence best known to the grower. At this stage it is a footless grub or maggot (see Fig. 16), waxy white or yellowish in color. The body is cylindrical, ending bluntly behind and tapering to a point at the cephalic end. When mature, it measures about .32 of an inch in length.

The Pupa.—The pupal or resting stage of the cabbage maggot is passed in the soil about the roots of the infested plant. Exceptions to this rule occur in the forms which assume the aerial habit and in the few which pupate in their burrows in the root. The pupa consists of a small brown case or puparium some .2 of an inch in length, elliptical-ovate in form and without the ability to move.

The Adult.—The adult insect varies considerably from the maggot that destroys the plant. It is a fly which appears to the ordinary observer not unlike the common house fly. It is considerably smaller in size, however, and when at rest the wings extend a greater distance back of the abdomen and overlap more.

The Egg is really very small, measuring only .04 of an inch in length. It is white, however, and by the keen observer may be readily seen lying on the soil close to the stem of the host plant.

Life History.

This insect passes the winter as larvae and pupae in and about the roots of their hosts. Possibly some of them pass the winter also as adult flies, hibernating in sheltered nooks about the field and in outbuildings. As the warm days of spring advance, the flies emerge from their hibernating quarters and also from the pupal cases in the soil, and seek their host plants for the purpose of egg deposition. The eggs are deposited close about the plant, the female fly working herself down below the surface, if the soil will permit, and placing the egg right against the plant root (see Fig 18). The eggs are often placed above ground on leaves or developing buds. The eggs hatch in from four to ten days, depending on the temperature, and the young larvae commence at once to burrow into the tender plant (see Fig. 17). The maggots reach maturity in a month to six weeks, pupate and emerge soon after as adult flies. From this time on until late fall one may usually find both larvae and pupae in the soil. As the season advances, a portion of the maggots assume an aerial habit. This is especially true in the fields when early cabbage has been harvested and where the stumps left standing have put out adventitious buds. The flies deposit eggs in these tender buds and the maggots burrow into the midribs of the leaves and into the core of the shoots.

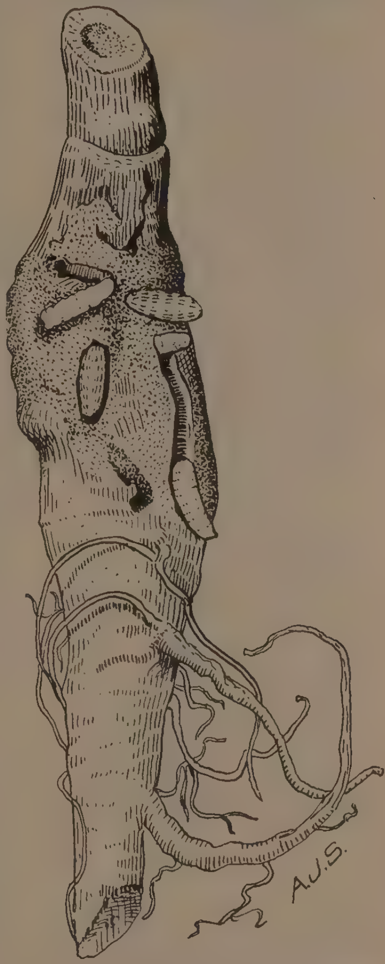

Fig. 17. The Cabbage Maggot. Root of wild mustard showing larvae, pupae and injury.

Control Measures.

Possibly for no other group of insects will one find such a variety of remedial measures suggested as for the root maggots, nor more diverse results following their application. No single remedial measure will ordinarily afford satisfactory relief. Combinations of preventive and remedial measures are best. A single application of any solution will seldom suffice; hence the crop should be treated again when the effect of the previous treatment is diminished.

Preventives.

Plowing of the infested fields as soon as the crop is removed will materially lessen next year's brood. The soil should be turned to a depth of four inches or more.

Destruction of Stumps.—The old stumps in the field or the refuse root crop in the soil should be destroyed. Such materials furnish ideal conditions for the development of this pest.

THE GARDEN SLUG.

By A. L. LOVETT.

(Limex agrestis Linn.) (?)

The garden slug, during a protracted wet spell, is a most annoying and destructive pest of garden crops. These repulsive, slimy, slow moving creatures are usually termed snails, but are properly called slugs.

There are several species of slugs and some snails which attack cultivated crops. Slugs occur all over the world but are more abundant and a more injurious pest in humid climates; their size and habits make it very easy for them to be transported from place to place. The one under discussion, if *Limex agrestis*, is an imported species.

The adult is about two inches in length and is a deep mottled grey or greenish grey in color. The body is covered with a mucus slime which is exuded from numerous glands on the body. This forms a slimy trail on whatever object the slug crawls. The head and body are contractile, the former bearing two contractile tentacles near the front. Just back of the head is a broad plate or mantle, with a small opening on the caudal lateral margin, known as the respiratory opening. The eggs are found in masses, but separate from one another, covered and held together by a transparent, slimy, gelatinous-like dressing. They are half the size of a garden pea, almost colorless and have a glistening transparency. The newly hatched slugs are about one-twelfth of an inch in length, and are lighter in color than the mature slug. They are not gregarious in habit, the young slugs each starting out independently as soon as hatched from the egg. The time taken to reach maturity varies from four or five months to a year.

The host plant list is a long and varied one. A variety of greenhouse plants are attacked, also many ornamental shrubs in the field. In garden and truck fields almost all crops may serve as hosts. The Cruciferae seem the favorite host, cabbage especially, and radishes to almost the same extent. Beets, beans, peas, corn and potatoes all suffer. Field crops of hops, wheat, clover and rape are common hosts. The small fruits are also attacked, strawberry plants often being injured severely during a wet season.

These pests locate at the surface of the soil, where they feed on the host and sap its energy. The feeding punctures thus formed afford a ready means of entrance for a decay that soon renders the plant worthless. I have found them feeding on the radish at a depth of three inches. During the night they come above ground. It is at this time that they attack the leaves of plants, often climbing up to the foliage of certain of the bush fruits. Young cabbages suffer most. Whatever the host, the evidence that this slug is the offender may usually be found in the coating of mucus left behind. Entire plantings are often devoured or rendered worthless by this pest and no season passes that the slugs do not collect a heavy toll. Dry weather checks their feeding, but does not cause them to cease operations entirely. As evidence of this I found them during our hot, dry period in midsummer up in the formed heads of cabbage, feeding on the cool, moist interior. At any time when the soil is again moist, they may appear in numbers.

Natural Enemies.

Birds are probably the greatest natural check we have for the control of the slugs. The thrush is especially fond of them. Moles and shrews also feed on these slimy creatures. Certain of the Carabid beetles and their larvae have been found feeding on the slugs. Centipedes also attack them occasionally. Domestic fowls will feed on the slugs and may sometimes be used to an advantage in checking them.

Control Measures.

With such a variety of host plants as is enjoyed by this slug and because of its general habits it is necessary to practice both preventive and remedial measures for its control.

Preventive Measures.—Remove the refuse tops, stumps, etc., after the crop is gathered. Clean up all weeds and trash about the fields and in fence corners. In my observations this season the point from which the original infestations seemingly took place was a strip of stinging nettles *(Utrica lyalli)*, about the borders of the field. The slugs occurred in the dense, cool growth all the season and in all stages of development.

Traps, consisting of pieces of board, sacking and similar materials may be placed about the field. The slugs will collect under these in the early morning and may be gathered up in a salt water solution or otherwise destroyed.

Remedial Measures.—A few preliminary experiments were undertaken to test the value of various substances for the control of this slug.

May 9, 1912. Collected slugs on vegetation. Divided into three lots in the laboratory and treated as follows:

Lot No. 1—Treated with a powder consisting of crude carbolic acid, 1 part; gasoline, 3 parts; and sulphur to form powder.

Lot No. 2—Treated with powder consisting of Black Leaf (old form), and sulphur to form powder.

Lot No. 3—Treated with tobacco dust.

No. 1—All dead in 2½ minutes.
No. 2—All dead in 4 minutes.
No. 3—All dead in 3 minutes.

May 12, at place of Mr. Wilkinson, across ferry: Treated cabbage plants for slugs as follows:

No. 1—Zinc arsenite spray:

Zinc arsenite	3 ounces.
Whale oil soap	1 pound.
Water	8 gallons.

The soap was dissolved in hot water and added to the solution to aid it in adhering to the foliage of the cabbage.

No. 2—The crude carbolic, gasoline, sulphur.

No. 3—The Black Leaf, sulphur.

The spray was applied to the cabbage with a small compressed air hand pump, using a fair pressure. The soil materials were simply worked into the surface soil about the plants.

All the materials proved of some benefit for a time. The spray was applied to the upper surface of the cabbage foliage and the slugs fed more or less on the under surface of the leaves. After a period of five days the soil materials had apparently lost their strength and slugs were feeding on the plants. The treated plants still looked better than the untreated ones. The zinc arsenite showed on the foliage for over two weeks and was of value sufficient to warrant more trials another season.

June 6. At place of Mr. Wilkinson, treated beans and radishes with the following materials:

No. 1—Air-slaked lime.
No. 2—Air-slaked lime, 5 parts; hellebore, 1 part.
No. 3—Air-slaked lime, 10 parts; hellebore, 1 part.
No. 4—Air-slaked lime, 5 parts; tobacco dust, 1 part.
No. 5—Air-slaked lime, crude carbolic, gasoline.
No. 6—Crude carbolic acid emulsion spray.

June 8. Report on treatment:

No. 1—Not effective; placed slugs directly in the dust and they were alive at end of an hour.

No. 2—Kills slugs, does not injure plants.
No. 3—A few live slugs, no injury to plants.
No. 4—A few live slugs, no injury to plants.
No. 5—Kills slugs, blisters plants severely, both bean and radish.
No. 6—Not effective, blisters plants severely.

Conclusions for the Season's Work:

1. Air-slaked lime five parts and hellebore one part gave ideal results. Air-slaked lime ten parts, hellebore one part, or air-slaked lime five parts and tobacco dust one part, are both very good and would possibly prove efficient.

2. The arsenical sprays, while not giving satisfaction in this preliminary test, are worthy of more and varied trials.

3. The air-slaked lime alone is unsatisfactory for our conditions west of the Cascades. Crude carbolic acid emulsion is not satisfactory, likewise the other soil materials tested.

Salt, air-slaked lime and salt, air-slaked lime 96 parts and caustic soda 4 parts, and tobacco dust, are among the materials recommended by various authors which seem to give very fair success.

Drippings are recommended by one authority, who suggests rubbing the grease over the underside of well grown cabbage leaves and distributing them about the field. The grease proves very attractive to the slugs which gather here in numbers and may be collected. It would seem that an arsenical poison might be added to drippings and the leaves thus serve as a poisoned bait.

Poison Bran Mash.—Consisting of coarse bran 16 pounds, paris green one pound, salt one-half pound, cheap syrup one gallon, and warm water to make a coarse mash, is good for cut-worms and should prove equally effective for the garden slug. The material may be placed in small heaps about the base of the host plants.

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MISCELLANEOUS INSECT PESTS OF ORCHARD AND GARDEN.

By H. F. WILSON AND A. L. LOVETT

THE OYSTER-SHELL SCALE.

(Lepidosaphes ulmi Linn.)

Probably as widely distributed as the San Jose Scale, this insect is the cause of much injury to fruit trees throughout the United States.

In some portions of Oregon it is quite common and may be found very abundant on unsprayed fruit trees. It receives its common name from the similarity in appearance to a form of oyster and is therefore readily recognized. (See Fig. 19.)

It is not supposed to be as serious a pest as the San Jose Scale, but is of considerable economic importance. Entire trees are seldom killed, but oftentimes single branches will become so weakened from their attack that they will not produce fruit and may die, and at times small trees become so stunted as to never grow into well balanced trees. Besides our fruit trees this insect infests a large number of shade trees, vines and bush fruits. The adult scales measure about one-eighth inch in length and are dark brown in color. In early spring these may appear grayish brown, due to bleaching by the winter rains. When present in large numbers the scales will overlap and assume various curved shapes. The life history has never been definitely worked out for Oregon, but we suppose that there are about two generations in Oregon, as this is the case in the eastern part of the United States. Apparently with the beginning of fall the entire abdomen of the female develops into eggs and the insect itself shrivels up and dies. If during the winter one of these scales be turned over, 50 to 100 small white oval eggs will be exposed to view.

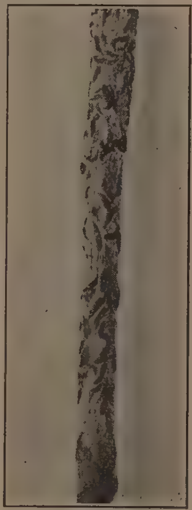


Fig. 19. The Oyster Shell Scale. (Original)

These eggs hatch about the time the blossoms of the apple are falling, and the young crawl from under the scales and settle on the bark. The female molts twice in her growth according to Quaintance and Marlatt, and in the adult condition is entirely without legs or eyes, and is but a jelly-like mass, capable only of extracting sap from the tree and changing it into eggs.

The adult male undergoes similar changes under its scale but later assumes legs, wings and antennae, and emerging from under the scale flies about fertilizing females.

In its distribution from orchard to orchard, nursery stock probably plays the most important part, although other insects, birds, etc., may and do aid in the distribution from tree to tree.

Remedies.—It has been stated that lime-sulphur will not destroy the egg of this pest but we have observed that where this spray is consistently used for the San Jose Scale that the Oyster-shell Scale does not thrive and no extra application is needed. No doubt but that the eggs are very tenacious of life and hard to kill, but we believe that the insect can be held in check with the above spray.

Shade trees and low growing plants, as currant, gooseberry, etc., often become so badly infested that it seems necessary to apply a spray. In such cases Kerosene Emulsion is used, and is applied just as the eggs are hatching in the spring. Considerable difficulty may be experienced here as the young are at that time, considerably protected by the foliage. To secure the best possible results a high pressure pump should be used by means of which a

pressure of 150 to 200 pounds can be secured. Apply spray to all parts in as thorough a manner as possible. (Use Kerosene Emulsion 8 to 10 per cent strength.) For preparation of Kerosene Emulsion see sprays for Aphis.

THE EUROPEAN FRUIT LECANIUM.

(*Lecanium corni* Bouché.)

In Oregon we have found this pest on prune only, and how bad a pest it may get to be is hard to say. It also attacks peaches and apricots as well as a large number of non-fruit trees. In California it is known as the Brown Apricot Scale because it seriously attacks apricot trees.

The adult females are brownish in color with a few black markings, convex in shape and oftentimes covered with a white powdery secretion. They measure about one-eighth inch in length, are slightly less than that in width and are raised about one-sixty-fourth of an inch. (See Fig. 20.)

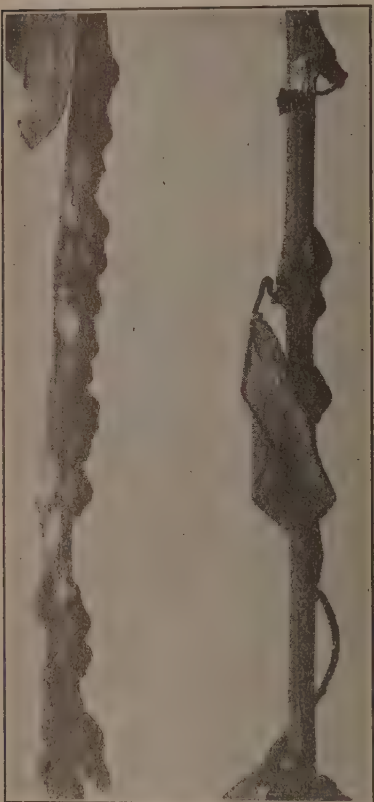


Fig. 20. The European Fruit Lecanium. (Original.)

Remedies.—Lime-sulphur is not very efficient against this insect and should the insect become a serious pest it will be necessary for us to adopt what is known as the Distillate-oil Emulsion Spray, which is made as follows:

Hot water	12 gallons.
Fish Oil Soap	30 pounds.
Distillate oil (28° Baumé)	20 gallons.

The fish oil soap is made as follows:

Water	6 gallons.
Lye	2 pounds.
Fish oil	1½ gallons.

The soap ingredients should be boiled for about two hours and produce about 40 pounds of soap. Use this at the rate of 6% distillate emulsion by taking 5¾ gallons of the concentrated emulsion and 44¼ gallons of water. Add one pound of caustic soda to soften the water. In mixing the original solution it should be driven through a force pump and back into the containing vessel in the same manner as Kerosene Emulsion is mixed.

THE PERIODICAL CICADA.

(*Tibican septendecim* Linn.)

There are probably very few of us who are not acquainted with this insect in the adult stage on account of the large numbers which appear at one time or another in various sections of the country. The name is applied on account of the fact that the adults only appear at periods of every 17 or 13 years. In the northern part of the United States it is 17, in the south 13. During the intervening time they live in the ground as nymphs and live by sucking the juices from the roots of trees. Having reached that point where they are ready to become adults, they crawl out of the ground and on to a stone, tree trunk or anything above ground, and shedding the skin for the last time, come forth as adults.

Fig. 21. Periodical Cicada: Egg punctures in twigs; pupal case and adult insect. (After Cordley)

After leaving the old shell they are ready to fly about in a day or two. and within a week the sexes have mated and the females shortly proceed to make their egg punctures and deposit eggs here and there in the twigs.

In selecting trees for egg oviposition oaks are shown a preference and among fruit trees apples seem to be preferred. Almost any plant may be attacked, although the sticky resinous sap of evergreens seems to have for the most part a prohibitive effect.

The part of the plant selected is almost invariably the twigs of the previous year's growth. Occasionally a single nest or two will be constructed in a larger limb.

The result of such work must of a necessity be quite detrimental to the trees as the twigs are often so weakened that they break very easily and an excessive pruning results. In the nursery considerable damage may be caused by the after-effect, which is shown in the deformities of slow-healing wounds. These wounds offer excellent entrance ports for fungus diseases and other insects. The woolly apple aphis often-times locate in these scars and instead of healing over they become more deformed and susceptible to the attacks of fungus and insects.

Fig. 22. Periodical Cicada: Egg punctures in young twig, and showing manner of breaking. (After Marlatt.)

In depositing her eggs the female cicada passes from one limb to another until she has deposited all of her eggs, which have been estimated to number from four to six hundred. The eggs measure about one-twelfth inch in length. They hatch in six or seven weeks, are pearly white in appearance, tapering to an obtuse point at either end and slightly curved. Owing to the thinness of the shell the form of the embryonic larva may be distinguished some time before hatching. Upon hatching from the eggs the young larvae run about for a very short time, drop to the ground where they

interspersed with black, and becoming more decidedly yellow laterally. From the center of twelfth segment a bundle of long yellow hairs, tufted with black; under side blackish; feet and pro-legs orange yellow, with the claws black. Length one inch."

When mature the larvae usually seek some protected place for forming their cocoons and in such a place collect in large numbers if very abundant. Occasionally they will gather bunches of leaves at the tip of twigs and form their cocoons under these; this takes place in early June. About the last of June the females and males emerge, copulate; and the females being unable to fly, remain hanging to the old cocoons. The males fly both at night and during the day; they live but a short time after copulation.

It has been stated that the males are attracted to the females by their odor and that they will go long distances to find them. As the eggs are deposited the females secrete a cement-like substance which surrounds the eggs and forms an excellent protection against climatic conditions and enemies. This also fastens them very securely to whatever they are laid upon. As the eggs pass from the body the abdomen contracts until the female is but head and legs with but a semblance of an abdomen. The egg masses are grayish brown in color, nearly spherical and measure about one-fourth inch in diameter. There is but a single brood each season and the eggs remain over until from early summer to early spring. There is little danger that this insect will ever become a very serious pest but it is at all times annoying and may at times need special treatment.

Remedies.—Our most common spray of arsenate of lead, two pounds to 50 gallons of water, is entirely ineffective and paris green is not much better. Contact sprays seem to be inefficient and there remains but two methods that offer any great chance of success: one is to collect or to destroy the egg masses. It seems barely possible that these can be treated the same as those of the Gipsy Moth, although we do not know that it has been tried.

Second, by placing sticky bands on the trees and then jarring the trees. These may be made of tangle foot or some tar compound. Jarring the trees will cause the larvae to drop to the ground and when the trees are banded they cannot get past the bands as long as they remain fresh.

THE TRUMPET LEAF MINER OF THE APPLE.

(*Tischeria malifoliella* Clemens?)

This insect is of little economic importance to fruit growers in Oregon, but sometimes appears very numerous on the leaves of apple and is often inquired about.

Little mines are made in the leaves by the larvae, which begin at the point of egg deposition and gradually widen out in the shape of a trumpet. Completed mines vary much in shape and size, but will average perhaps in the more typical examples one-half inch long by one-fourth inch wide.

The larva is whitish in color with a brown head, and measures about one-quarter inch in length at the time of pupation. The adult was originally described as follows: "The head and antennae shinning dark brown, face ocherous. Fore wings uniform shining dark brown with a purplish tinge, slightly dusted with pale ocherous citio of the general hue. Hind wings dark gray; cilia with a rufus tinge."

When excessively abundant, as has been the case in several localities during the past two or three years, the injury done by the larvae to the leaves will cause many of them to fall prematurely, thus interfering wit h the proper development of the fruit and the health of the tree. Its control, therefore, becomes a matter of importance. This can, perhaps, best be accomplished by plowing the orchard in the spring, covering as much as possible all the fallen leaves and trash, as in the former the pupae pass the winter. This having been done it is practically certain that the moths will not be able to make their escape from the soil. This should be done not later than the blooming of the trees.

THE CANKER WORM.

(Notolopus sp.)

In the early spring, after the apple leaf buds have opened, we often find numbers of little darkish colored measuring worms, which feed on the leaves. These are called canker worms and are apparently different from our eastern canker worms. The eggs of this insect are deposited on the trunks and leaves and hatch in the spring. When first batched the larvae are very small and such feeding as they do is not apparent. As they increase in size the entire leaf, with the exception of the midrib and larger veins, are devoured. About four weeks after hatching the larvae are full fed and then drop to the ground, enter to a depth of a few inches and pupate. They remain here until late fall or early spring, when they change to the adult insect. The eggs are deposited in masses by wingless moths of sluggish appearance that gradually crawl up a small twig, depositing the eggs as they move forward.

Fig. 27. The Canker Worm: Larvae feeding on leaves. (After Cordley.)

The female moth is brownish in color with a slight tinge of gray and measures about three-fourths inch in length. The male moth has not been observed. As the female moth is unable to fly, this species is distributed very slowly, and since the larvae readily succumb to arsenical poisons, there is very little chance for this pest to ever become very serious.

EYE SPOTTED BUD MOTH.

(Tmetocera ocellana Schlieff.)

The larvae of this moth resemble those of the Peach and Prune Twig Miner quite closely, and they are often mistaken one for the other, but the latter work only on the stone fruits, while the former work on practically all of the orchard trees. By careful examination they can readily be distinguished by the anal shield, which on the above insect is shining black like the head and thoracic shield, while that of the twig miner is the same as the rest of the body. When fully grown, the larvae are one-half inch long and of a dirty gray color. They are not yet full grown with the opening of the buds in spring and will feed upon the blossoms during the entire blossoming period. They may mat the blossoms and leaves of a cluster together with their silken threads within which they feed, making it difficult to reach them with spray.

Life History.—The larvae, like those of the twig miner, winter on the twigs and branches in an immature condition, but while the twig miner

excavates a cavity in the bark, the larvae of the bud moth form minute inconspicuous cocoons on the bark. This is a peculiar habit of a few larvae that form cocoons before reaching maturity.

As the buds start in spring the larvae leave their winter quarters and begin feeding upon the outcoming leaves and blossoms. They mature in early May, pupate, and in from 10 to 14 days appear as adults. The moths deposit eggs in late May and early June, probably upon the leaves (although this has not been determined). The young larvae feed on the under surface of the leaves and skeletonize them, especially in the vicinity of the midrib. So far as known, there is but one generation, although from the shortness of the life cycle, it is apparent that moths from the first brood might produce a second generation that would mature in time to deposit eggs for the spring forms.

Remedies.—There are three methods of control. The first is to spray the trees before the buds start in spring in order to destroy the overwintering larvae. One application of crude oil emulsion or kerosene emulsion, applied just before the buds start, would be the most effective means for this.

The second method is to spray with arsenicals when the larvae are feeding upon the foliage and blossoms, but they are sometimes hard to reach, especially when they have matted the blossoms together. The pome fruits that are well sprayed for the codling moth will not be bothered with the bud moth.

Third. Recent experiments tend to show that the best time to spray for this insect is in the fall at a time when the larvae are working on the under side of the leaves. This spray applied about September 1, will also help to catch a great many codling-moth larvae.

THE RED-HUMPED APPLE TREE CATERPILLAR.

(Oedemasia concinna S. & A.)

As yet this insect has not reached a very important status as a pest, but it is more or less generally distributed in fruit growing sections of the United States. At times they may get into an orchard and strip a great many branches, as they are voracious eaters, feeding on apple, plum, cherry, rose, thorn pear, blackberry, birch, poplar, etc.

The adults are moths of rather a mixed brown color, fore wings dark brown on the inner and grayish along the outer margin. The thorax and abdomen are brown. The moths appear in the middle of the summer and deposit their eggs in clusters on the under side of the leaves. From these soon hatch little larvae or worms, which feed on the under side of the leaf. Later as they grow larger, the whole leaf excepting the midrib, is devoured. In October they become full grown, descend to the ground, crawl under leaves or rubbish, where they construct a clear transparent cocoon, and remain until the following spring, when they appear as moths.

The full grown caterpillar measures about one and one-fourth inches in length. It is marked with fine longitudinal stripes of black, white, and yellow. Head bright red, and contracting upward and backward. Body covered with black tubercles, which on the dorsum carry black spines. The fourth body segment is raised dorsally to form an oval red hump from which the insect gets its common name.

Remedies.—Arsenicals applied to the leaves are efficient and probably the reason that we seldom hear of this pest doing serious damage is because they are poisoned by the sprays used for codling moth, etc.

THE OBLIQUE-BANDED LEAF ROLLER.

(Cacoecia rosana Harris.)

Appearing on various plants throughout the United States we may expect to find the larvae of this insect working on the leaves of all of our cultivated pome, bush and small fruits. In extreme cases some little damage may be done to apples and pears. In these cases the skin of the fruit is eaten and even holes are made in the fruit which makes it unfit for sale.

The Adults have a wing expanse of about one inch. General color leather

colored brown with one opaque dusky band, beginning at the middle of the anterior margin and extending to the inner angle of the wing.

The Larvae are pale green to reddish brown in color, with a dark brown head and a few sparse hairs rising from the head and body. The larvae of this insect should not be mistaken for that of the bud moth, which is a very abundant insect in Oregon found working in the buds. The larvae of this insect work on the leaves.

Remedies.—Should this insect become abundant at any time it may easily be controlled by an application of spray as used for the codling moth.

THE WESTERN PRUNE AND PEACH ROOT BORER.

(Sanninoidea opalescens Hy. Edw.)

Reported only from some four or five extreme Western states, we have another insect which so closely resembles an eastern species as to be distinguishable only by the absence of a distinct orange colored band across the abdomen. Perhaps very few orchardists have ever seen the adult of the borer, although every peach and prune grower has no doubt had the pleasure of digging out the larvae from the roots of his trees. The habits of our western species vary only in a few immaterial differences from those of the eastern. The borers of both seem to attack trees to a greater extent in light sandy or gravelly soils. Peaches are most susceptible to attack, although prunes and apricots seem to be a close second. Almonds, cherries, apples and native plums may be attacked. Myrobalan plum trees are but very little bothered under normal conditions and should be used as stocks upon which to graft domestic plums.

Fig. 28. Prune and Peach Root Borer: 1, larvae in burrows taken from peach tree; 2, cocoon pupal case and adult. (Original.)

The adults or moths emerge in midsummer; at that time they are metallic black in color, fore wings transparent with black margins; hind wings trans-

parent with a black border. Under side of wings same as upper. They may often be seen resting on leaves or trunks of trees. Soon after emergence the sexes mate and as soon as copulation takes place the female moths begin to lay their eggs on the bark close to the crown of the tree. Oviposition is finished in a few days and then the moths die. The egg stage lasts about two weeks and the newly hatched larvae start in at once to locate suitable places for entering the bark. Within a couple of hours they are able to disappear under the frass thrown out in starting their burrows. The majority of the larvae work below the surface of the soil before entering the bark and will always enter an old burrow if one is handy. In rare instances larvae may be found working in the trunk and larger branches. Under the bark the larvae work upward or downward and may work up the trunk as far as twelve to sixteen inches, eating away all of the sapwood. One tree may have as many as seventy borers working on it at one time. Apparently the larvae feed at random, as there is no regular shape to the burrow; they may be long, wide, narrow, large or small, and more than one borer may be found in the same burrow. As fresh castings can nearly always be found at the opening the larvae evidently clean house every day. This mixed with the gum nearly always indicates where burrows can be found. When full fed the larvae leave the main part of their burrows, seek places where the adults can escape, form cocoons out of silken threads and chewed bark or pieces of soil, line them with silk and pupate. The cocoons are elongate oval in shape and about an inch in length. Pupation usually takes place about June 1. The pupal stage lasting about four weeks.

Remedies and Preventives.—The life history of the western species is so similar to that of the eastern species that probably what has been learned regarding methods of control there, will be applicable here. For more than 100 years many preventives have been recommended, such as whitewashing the bark of trees, painting, wrapping with cloth, daubing with tar and other sticky substances, and many others, the purpose of all of these being to prevent the moths from depositing eggs or to destroy the larva before it could enter the bark.

A few years ago the Cornell Experiment Station tested eighteen or twenty of the most promising of these preventives through a period of four years, and came to the conclusion that none of them could be relied upon entirely. The best preventive they found was gas tar daubed upon the bark. It has this disadvantage that it sometimes kills the tree. The next best preventive was to wrap the trunk with waste tobacco stems and leaves, which is an expensive process. The third best method was to wrap the trunk with tarred or other paper. In every instance, however, it seemed to be necessary to supplement these preventive measures with the remedial one of digging out the borers. They came to the conclusion that washes and poisonous substances with a disagreeable odor were practically useless as preventives. They may be right, but here we have quite good results both from the use of whitewash and paris green, and by spraying the bark with thick Bordeaux mixture and paris green. It was supposed that the value of the spray lay in the poison, and by thorough spraying it becomes impossible for the larva to enter without getting a poisonous dose. Slingerland says no.

Mr. Daly, who was for a number of years horticultural commissioner of the first district in this state, and an extensive fruit grower, practicing digging out for a number of years, decided to try the preventive effect of wrapping the trees with paper or burlap. After doing this for two years in a thirty-five acre orchard, he wrote Professor Cordley that while expensive, it was cheaper and more effective than digging out. There are two chief difficulties in the digging out method. 1. At whatever period one does the work, there will be many small larvae which will be undiscovered, thus necessitating for the best results that one go over the trees two or three times during the season. 2. It necessarily does more or less injury to the tree. According to Cornell results, however, this is the only satisfactory method that can be used, and should be supplemented with one of the preventive methods.

Professor Woodworth of California recently advocated the use of carbon

bisulphide. The method was first recommended by Professor Cook at that time of the Michigan Experiment Station, but it seemed to be expensive and, according to the Cornell experiments, valueless. This method is now discouraged.

The United States Bureau of Entomology now recommends three formulas which are being used in various parts of the country against borers. They should be applied just after worming.

"**Formula No. 1.**—The lime-crude oil mixture; place about fifty pounds of rock lime in a barrel and slake with ten or fifteen gallons of warm water; while the lime is boiling, slowly pour in six to eight gallons of heavy crude oil and stir thoroughly. Add enough water to make the whole a heavy paste. The wash should be applied immediately with a heavy brush.

Formula No. 2.—The lime-sulphur-salt mixture. Place about twenty-five pounds of rock lime in a barrel and slake with warm water. Add two quarts of sulphur and two or three handfuls of salt while the lime is still boiling. This wash is heavy and is applied with a brush.

Formula No. 3.—Lime, coal tar and whale oil soap. Unslaked lime fifty pounds, coal tar one and one-half gallons, whale oil soap twelve pounds. Slake the lime in warm water and add the gas tar while the mixture is boiling; dissolve the soap separately in hot water and add this to the lime solution. Add enough water to make a heavy paste."

THE BRONZE APPLE TREE WEEVIL.

(*Magdalis aenescens* Lec.)

Like many of the common insects found in Oregon, this insect appears to be a native of the northwest, and has only been reported from Oregon, Washington and British Columbia. When first noticed, it was reported as destroying whole apple orchards, but later observations show that most of the feeding occurs in the bark. In many instances the bark appears to be dead before the weevils make their egg punctures, but it has also been noticed that healthy bark affords suitable places for egg deposition and several growers in the Willamette Valley report serious injury to apple trees.

If one notices the egg cells, as shown in Fig. 29, and cuts away the bark, the larval galleries can be easily traced to where the larvae are feeding.

The egg cells are made by the female weevil, which eats out circular burrows to a depth of .08 inch. The eggs are then deposited singly in a few of the pits and the young white larvae hatch from these in a week or two. They feed and develop in these burrows until fall, when the larvae hibernate over, pupate in the spring and change to adults.

The adult insect is an elongate bronze black beetle, measuring about one-fifth inch in length.

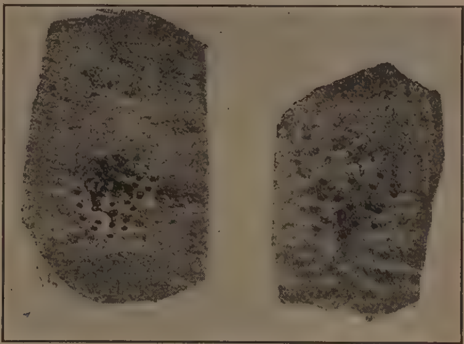


Fig. 29. The Bronze Apple Tree Weevil; showing egg cells in bark of apple. (Original.)

Methods of Control.—Careful examination of trees in localities where this insect is found and cutting out the infested areas appears to be the most satisfactory method for combating this pest.

THE CHERRY FRUIT FLY.

(*Rhagoletis cingulata* Loew.)

We have had some little inquiry in the last year or two upon worms in cherries. Unfortunately, due to the habits of this insect, the grower does not know of its presence until the cherries are mature. If left to hang on the tree or uneaten for several days after picking, the presence of a full grown maggot is shown by the rotting and shrinking of one side of the fruit, and about that time the maggots leave the fruit for the purpose of going to the ground, where they pupate and remain over winter. The adult fly resembles the common apple maggot very closely and may prove to be the same insect. Somewhat smaller than the common housefly, the general color is black with lateral borders of thorax light yellow, and head and legs yellowish-brown. Wings with five, more or less distinct black bands, three of which lie angled to each other and join at the front edge of the wing near the tip. These flies deposit the eggs from which the yellowish white maggots or "worms" issue and work in the fruit around the pits. This causes a kind of rotting and softening of the fruit on one side.

Just when the fruit is entered is not known, but the life of the maggot is probably about three weeks, and as the mature stage is reached about the time the fruit is ripe, some idea of the time they enter the cherry may be gained. Since the larvae remain in the fruit for a short time after it is picked they may be distributed quite a distance in fruit. The adults are not strong fliers and can hardly do more than to spread from tree to tree or at the most from orchard to orchard.

Remedies.—No very satisfactory remedy is at present known, although a great many have been tried.

THE FRUIT TREE LEAF SYNETA.

(*Syneta albida* Lec.)

Although this insect has been doing quite a little damage for some time, there are practically no published notes on its habits and life history.

The adults suddenly begin to appear in the spring at the time when the apple blossoms are opening and are very abundant for a few weeks, when they suddenly begin to disappear and in a few days can only be found in scattering numbers.

We have been unable to locate the eggs but suppose they are deposited in the ground upon roots of some kind. During 1912 larvae dug from the ground beneath apple trees formed into pupae and later changed to the adult stage. At that time it was impossible to tell whether the larvae were feeding

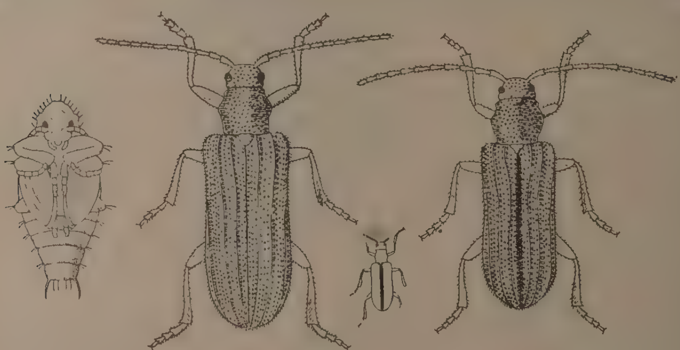


Fig. 30. The Fruit Tree Leaf Syneta: Pupa and adult. (Original.)

ıpon the roots of apple or upon the roots of some grass or weed, as the roots of all three were more or less intermingled. A number of larvae were found ıt a depth of fourteen inches below the surface of the ground.

The only injury which we are acquainted with is that done by the adults ınd at times this is quite serious. When the blossoms are opening in the spring, he adults can be found feeding on the petals and one would suppose that the ruit would suffer as a result, but apparently the principal parts of the flower re left uninjured. Later in the season the leaves of apples and prunes are the rincipal parts eaten, and oftentimes trees will have nearly every leaf with rom one to several holes eaten out. The worst and most serious injury is lone to young grafts, especially where whole orchards are being grafted over. These grafts where the leaves are continually eaten away for several years re killed, and consequently the tree itself is lost.

Remedies.—Such remedies as have been tried are more or less unsatisactory. Arsenate of lead in ordinary strengths fails to destroy the beetles, ınd stronger strengths seem to be only partially successful. With young grafts the beetles can be kept away by the use of cheesecloth sacks placed over the grafts.

THE BRANCH AND TWIG BORER.

(*Polycaon confertus* Lec.)

Although apparently never doing any amount of damage this insect is often found attacking the stems and branches of pome fruits and even grapes. Nothing is known of its life history n Oregon, but in California the larvae vork in live oak trees and it is very ikely that they do the same here. The adult beetles start in to burrow ıbove the buds and excavate a shalow burrow downwards, rarely deeper han the length of the body. This ourrow is about one-fourth inch in liameter and why it is made is not nown unless it is for the purpose of eeding, as they apparently never leposit eggs in them.

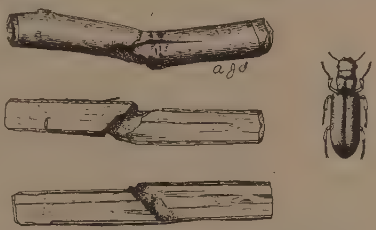


Fig. 31. The Branch and Twig Borer: Adult and work on young twig. (Original.)

They have never been abundant nough to cause any great alarm, but he burrows offer excellent opportunity for the entrance of fungi and decay organisms.

There is no known method of prevention.

THE RASPBERRY ROOT BORER OR BLACKBERRY CROWN BORER.

(*Bembecia marginata* Harr.)

This insect has appeared in certain of the bush fruit districts of Oregon, ınd while it is at present confined to a rather limited area, it will without loubt spread and eventually become a serious pest. The larva or borer of his insect tunnels into the canes, crowns and even the lateral roots of the lackberry and raspberry, eating out the pith and weakening the entire plant ystem. Only in severe cases do they kill the plant outright, their presence sually being first indicated by the wilting or death of an occasional cane or y the smaller size and inferior quality of the berries.

Life History and Habits.—The adult of this borer is a rather attractive lear-winged moth, nearly three-quarters of an inch in length and bearing to he ordinary observer, a close resemblance to a wasp. The head and thorax re brownish black. Around each eye is a yellow ring, the antennae are black. The abdomen is colored with alternating rings of yellow and black. These dult moths commence emerging from the pupa cases about the middle of ıly and individuals continue to appear until late September. These adult

CUTWORMS.

Cutworms are a very serious pest of nearly all our crops. Ornamental shrubs, garden and truck crops, field crops and even small fruits and orchards suffer from the attack of these pests. The sleek, well fed, greasy caterpillars, varying in size, when mature, from one to two inches, are too well known to require a description. The adult moths are nocturnal in habit, flying mostly at night. The majority of the medium sized, smoky grey and brownish moths, which are attracted to the lights, are adults of the cutworm caterpillars.

Remedies.—The poison bran mash, consisting of bran 16 pounds, paris green one pound, salt one-half pound, cheap syrup one gallon, and warm water to make a coarse mash, is the standard remedy for cutworms. This may be placed on a field prepared for a crop or may be placed about the base of the plants when they appear Poultry should not be allowed free range over a treated field. Green succulent forage of any kind may be sprayed with an arsenical, mowed and placed in small heaps about the field, preferably in the evening. Where these methods are impractical arsenical sprays applied to the host are of some assistance. For young plants just set in the field, as cabbage and tomato, a mechanical barrier consisting of a cylinder of tin or cardboard may be shoved down about the plant.

For the climbing cutworms, which attack the developing buds of our fruit trees in early spring, the poison baits are very good; but better still, is a belt of some sticky material about the trunk of the tree, or some mechanical device such as a piece of cardboard attached funnel shaped, tight at the top and flared below. Cotton batten may be used in a similar manner. Wrap a strip eight inches wide about the tree overlapping it at the edges where it meets. Tie this band at the lower edge, then, taking hold of the upper edge, roll it down over the bottom edge. This makes a very effective funnel.

GRASSHOPPERS.

Grasshoppers respond to about the same treatment as the cutworms. The poison bran mash is especially effective. It should be scattered in small drill rows at right angles to their course of travel. Trees may be sprayed with an arsenical, preferably lead arsenate, using it fairly strong.

CABBAGE WORMS.

Numerous reports of injury to cabbage and allied Cruciferae by cabbage worms are received every season.

Remedial Measures.—For very small plants use paris green one pound, and air slaked lime, road dust or cheap flour 20 pounds. Mix thoroughly and dust over plants by sifting through a coarse sack. This material will adhere better if applied in the early morning while the dew is on.

For older plants the regular arsenical sprays may be used, adding a little soap to aid them in sticking, or better still, use the resin lime mixture prepared as follows:

Stock solution:

Pulverized resin	5 pounds.
Concentrated lye	1 pound.
Fish oil soap or any cheap animal oil, except tallow	1 pint.
Water	5 gallons.

Place the oil, resin and one gallon of hot water in vessel for cooking. Heat until the resin is softened, add the lye solution made as for hard soap, stir thoroughly and add four gallons more of hot water. Boil for two hours or until the mixture will unite readily with water, making a clear amber liquid. Add water to make up for that lost by evaporation. This constitutes the stock solution and may be kept indefinitely. In applying it, for every gallon of the stock solution add first 16 gallons of water, then three gallons of thin whitewash and one-quarter pound of paris green.

Hot water at a temperature of 130 Farenheit will kill the worms and will not injure the cabbage plants.

WIRE WORMS.

Elateridae.

Fields are sometimes found infested with elongated, worm-like larvae with a hard, smooth, reddish brown surface. The segments are very well defined and on the first three, just back of the head, are a pair of short, stout legs. The head is flattened, wedge-shaped and fitted with a pair of powerful jaws, which enables the insect to bite roots and tubers with great ease. These wire worms vary from one-half inch to an inch and a quarter in length, are active, strong and hard to hold.

Remedial Measures.—A well planned rotation of crops, with the object of getting as far as possible from the grass family, is recommended.

Traps, consisting of boards or stones placed about the field with poison dainties beneath them, such as bran mash or some sprayed succulent crop, are good.

Salt, at the rate of from 250 to 500 pounds to the acre, or even in greater amounts, is recommended by some of the successful onion growers as an effective remedy for wire worms. No careful experiments have so far been undertaken by this station, however, and we can not commit ourselves as to the value of this treatment.

NUT INSECTS.

The nut industry is so new to Oregon that we have apparently been overtaken with but very few of the insects which we expect to find infesting the nuts grown in Oregon.

On walnuts we have only observed two insects and we can hardly call either of them serious.

THE WALNUT CALLIPTERUS

(Chromaphis juglandicola Kalt.)

This is a little green plant louse about one-eighteenth inch long which feeds on the leaves of walnuts throughout the summer. The life history has never been worked out but we believe that it is about the same as other species of this group. The winter is spent in the egg stage on the twigs about the buds. As the buds are turning green in the spring little greenish yellow lice issue from the eggs and crawling to the opening buds feed on the expanding leaves. Towards late spring winged individuals appear and migrate to other trees, where they produce living young. During the summer and until late fall viviparous females are produced. Then more winged forms appear, which produce true males and females. The males have wings but the females are wingless. Copulation takes place and the overwinter eggs are deposited by the females about the buds on the young shoots.

Remedies.—Spray with "Black Leaf-40" or Kerosene Emulsion 10%.

THE WALNUT SCALE

(Aspidiotus juglans-regiae Com.)

This insect is found in two or three localities of Oregon but as it has never been a serious pest in other sections of the United States where walnuts are grown, we do not believe that spraying will be necessary for some time. The scale of the female is circular, flat, with the nipple slightly out of the center. The major part of the scale is pale grayish brown with the nipple reddish brown, diameter of scale .13 inch. The scale of the male resembles that of the female in color but is elongated and is narrower. Length of scale .05 inch.

Remedy.—Lime-sulphur as used for San Jose Scale may be used with success when trees are dormant.

SOME VERY SERIOUS INSECT PESTS LIABLE TO BE INTRODUCED INTO OREGON.

By H. F. WILSON.

THE GYPSY MOTH.

(*Porthetria dispar* Linn.)

Like many other of our most serious pests this insect was imported from Europe and has been the cause of considerable trouble in this country. We do not as yet have this pest in Oregon, but everyone is warned to be on the lookout for it and a description of the various stages is given below so that anyone may be able to recognize it.

The eggs are deposited in masses measuring three-fourths by one-half inches and containing approximately 500 eggs. They are covered over with a sticky fluid secreted by glands in the body of the insect, to which is added the yellow hairs taken from the body of the moth, and when the moths are abundant, may be found on the bark of trees, old fence corners, under stones, etc. At first these egg masses are yellowish in appearance but during the winter, exposure to the weather causes them to become a dingy white. The individual eggs are about the size of a pinhead, and when first deposited are salmon colored, turning dark in the course of a few weeks.

These eggs hatch in the spring and each egg mass produces a mass of young dark caterpillars, which become full grown by midsummer. The caterpillars are decidedly hairy and as they grow older assume a varied coloring along the back. Starting from the head which appears mostly yellow, may be found a double row of five pairs of blue spots; these become very distinct on the larvae as they reach maturity and as the larvae are entirely distinct from any others which we have in Oregon, they should be easily recognized if one meets with them.

When full grown, which is in midsummer, the caterpillar spins a few strands of silk for support and changes to a chrysalis, which is the pupal stage. In this stage they are dark reddish in color and thinly sprinkled with light reddish hairs. They remain in this stage for about two weeks and then change to the adult insect. The female moth is white with numerous black markings, is quite robust and moves about very sluggishly.

The male is brownish yellow with sometimes a greenish tinge. They fly about during the day and after mating with the females live but a very short time. The males measure about one and one-half inches from tip to tip of wing. The females measure about two inches but do not fly and therefore do not spread as rapidly as they might. After copulation takes place the females deposit their eggs and die.

This pest is probably mostly distributed by egg masses on nursery stock, but as the larvae have a habit of spinning webs and dropping from trees they are oftentimes carried on automobiles and other vehicles for long distances.

The gypsy moth caterpillar will attack all fruit, shade and woodland trees. Apple trees seem to be preferred above all others. It will also devour at times grasses, flowers, shrubs, vines, bush, garden and field crops.

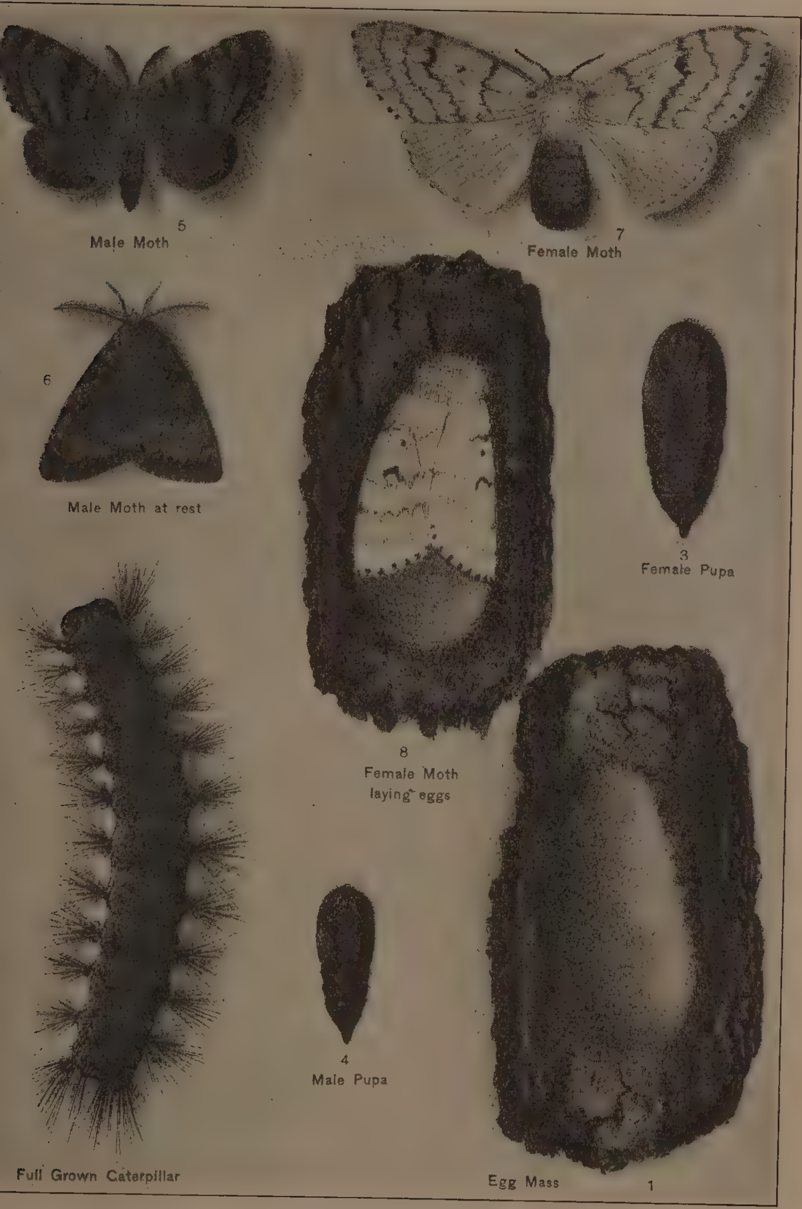
Deciduous and coniferous forest trees are so thoroughly stripped of their foliage that they die as a result. The conifers will not withstand one thorough stripping and three consecutive strippings of deciduous trees are about all they can withstand.

There are many natural enemies of the gypsy moth and in Europe these are sufficient to keep it under control.

In the United States it will be necessary to wage combat until such natural enemies as are being imported can increase to numbers corresponding to those of the gypsy moth.

Remedies.—The most effective time to catch this insect is in the egg mass. These wherever accessible, can be killed by soaking them in creosote. When the caterpillars are quite small they can be poisoned with arsenate of lead at the rate of ten pounds to 100 gallons of water. This can be applied with any of the common force pumps.

Plate X.



THE GYPSY MOTH.
Showing all stages from egg mass to adult Moth. (After F. W. Rane.)

THE BROWN TAIL MOTH.

(Euproctis chrysorrhœa Linn.)

It seems passingly strange that we should have at the same time two insects whose depredations are so similar and equally disastrous as in the case of the gypsy and the brown tail moth. Accidently introduced into this country along in the nineties on nursery stock imported from Holland; the latter insect has become one of our worst insect enemies of orchard, forest, ornamental and shade trees.

We hope that Oregon is so far distant that the brown tail moth will never reach us, but taking into consideration the fact that the insect is nearly world wide in its distribution, and that already some eighteen or more nests of over-wintering young have been brought into Oregon on nursery stock, it would seem more than probable that we will some day have this pest to fight.

The life history is somewhat different from that of the gypsy moth, as the eggs hatch during August and the larvae live over winter in nests of leaves drawn together by silken threads. The eggs are globular in shape and quite small; they are laid in masses on the under side of the leaves along in late July and early August. Each mass contains approximately 300 eggs, is brown in color and covered with numerous brown hairs taken from the body of the moth. The egg masses are much smaller than those of the gypsy moth, more elongate and measure two-thirds inch in length by one-fourth inch in width. The larvae when first hatched are black with reddish brown hairs dorsally placed; on the fourth and fifth segments one may find a single large tuft of brown hairs, and on the middle line of the ninth and tenth segments is a reddish tubercle which may be withdrawn into the body.

When full grown the larvae measure about two inches in length, are reddish brown in color with two red spots on the back near the rear end, and with a longitudinal row of white markings on each side of the abdomen. The body is also covered with numerous tubercles bearing long barbed hairs. The tubercles along the back and sides of the abdomen are thickly covered with short brown hairs in addition to the longer ones. These short hairs are the ones known as the "nettling hairs."

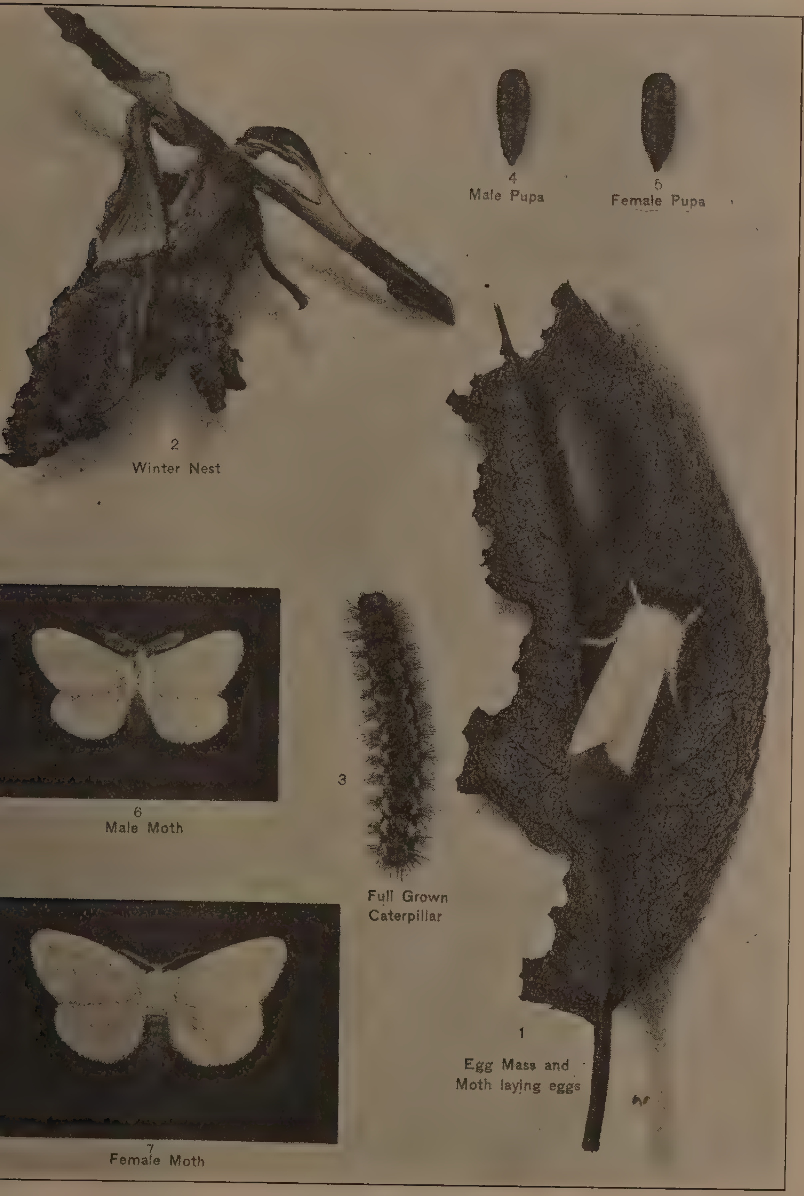
About the middle of June the larvae spin silken cocoons among the leaves and then pupate. Here they remain for about twenty days, and begin to appear as moths about the middle of July. Both the males and the females are pure white, with the exception of the abdomen, which is brown at the tip; on account of these brown tips the moth is known as the brown tail moth. The females have a wing expansion of about one and one-half inches, the males one and one-third inches.

As soon as they have copulated the females begin depositing the eggs on the under side of the leaves. These hatch in about three weeks and the young larvae immediately begin feeding on the leaf bearing the egg mass. After a short time they wander to other leaves and feed, returning to the old leaf at night. Toward fall they begin forming the winter web in which they leave exit holes so that they may go out and feed during good weather.

The Principal Means of Distribution to any distance is made by the importation of nests on nursery stock. In localities where this pest does not exist one or more dried up branches of leaves may be passed as perfectly harmless and the trees having been set out, the larvae have simply to wait for the blooming of the trees and then their continuance is assured. Having once established themselves they have but little difficulty in getting from orchard to orchard, as both males and females are strong fliers. It is said that they have a habit of soaring above the tree tops and buildings and so are carried long distances by the wind. They are also attracted to lights and so are distributed by trains and electric cars into which they fly when opportunity offers. In other respects they are distributed as is the gypsy moth.

Food Plants.—Pear and apple are the favorite food plants of this insect, but nearly all fruit and shade trees, excepting the conifers, are attacked. The injury is not as serious as that caused by the gypsy moth, but is sufficiently serious to need treatment.

Plate XI.



THE BROWN-TAIL MOTH.
Showing all stages from egg mass to adult moth. (After F. W. Rane.)

Not only are the larvae of this insect a serious pest on trees, but they are dangerous to the health of any community in which they exist. A part of the hairs covering them are furnished with very minute barbs. These remain in the cast skins after molting takes place and as the skins dry they become loosened and are blown in all directions. When these hairs touch the skin they cause an irritation which increases with rubbing to a degree where considerable annoyance and pain may be experienced.

Methods of Control.—Collecting and destroying the winter nests seems to be the best method and supplemented with spraying for the newly hatched young offers a means whereby this insect can be held in check. Uninfested trees can be protected by applying bands of some sticky substance as tanglefoot or tarred bands.

THE MEDITERRANEAN FRUIT FLY.

(*Ceratitis capitata* Wiedemann.)

In countries where this pest has gained a foothold it is one of the greatest insect enemies of fruit raising. At the present time it is believed that Brazil is its native home. Adults have been reared from apricots, peach, pear, plum, apple, fig, oranges, lemons and a number of other important fruits.

Means of Distribution.—From evidence gathered in various sources the pest is distributed in fruit. An extract from bulletin 28 of the Department of Agriculture, Cape of Good Hope (South Africa), will show the danger to fruit growing in the United States should it gain a foothold. "It is no doubt carried into distant localities in infested fruit. Visit almost any morning market in the Colony after apricots and peaches are ripe and you can find maggots and puparia in abundance. That this fruit is purchased and shipped to other places, or carried away in small lots goes without saying. While visiting one of our most important markets on a Saturday morning during February, 1904, I found loads of infested peaches. There was absolutely no sale for the most of them, and the growers in disgust dumped them out on the ground. I said nothing, for, in the first place, I had absolutley no right or authority in the matter, and secondly, I wished to note the course of events. They were being removed by seven o'clock Monday morning, but the ground for yards around was dotted white with maggots trying to hide away for transformation, and puparia could be picked up by the hundred. Under such a deplorable state of affairs it is quite possible that some of the adults would again find their way into wagons and be carried away to distant farms."

The adult fly is yellowish with black and white markings. Both wings being banded with yellow and with a series of black lines toward the base. The abdomen is yellow and is crossed with two white bands.

The larvae or maggots resemble those of any of our common flies, such as the cabbage root maggot.

The Life History in general is about as follows: The eggs are deposited in the fruit by means of the sharp ovipositor with which each female is furnished. As soon as they hatch the young larvae at once begin to feed on the pulp of the fruit. When fully developed, which usually requires about three weeks, they leave the fruit and enter the ground where they change to puparia and later to adults. The adults push up through the soil and in a short time are ready for work. A very efficient remedy has been found for this insect in South Africa which prevents the adults from depositing their eggs.

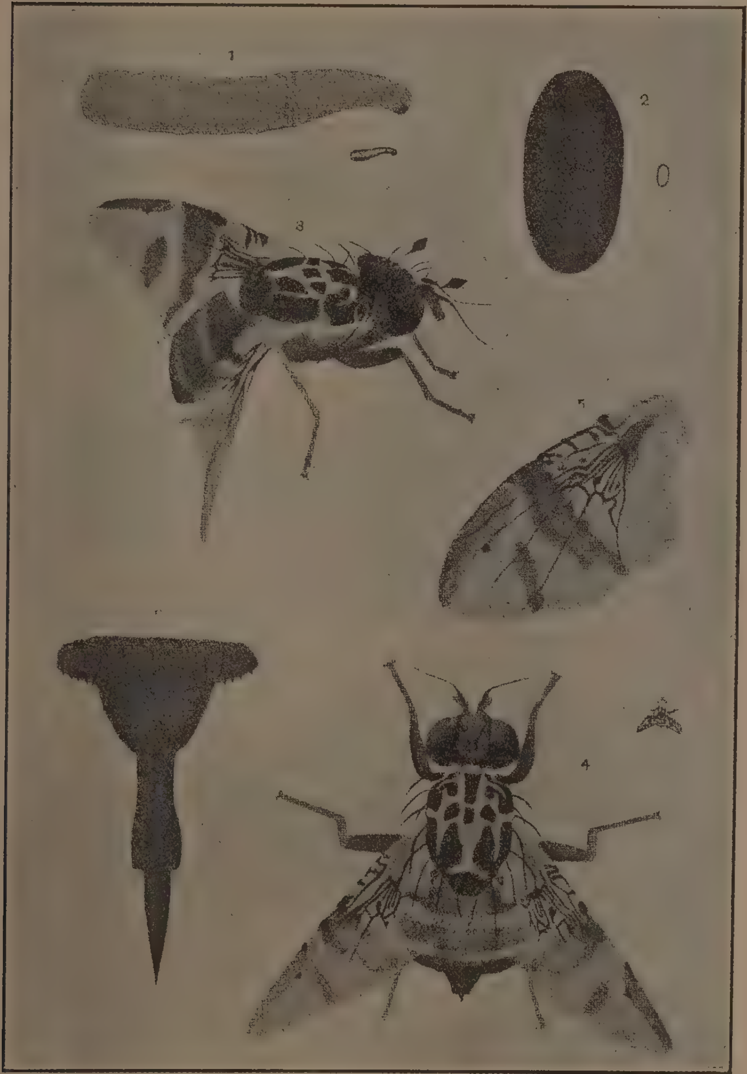
THE PLUM CURCULIO.

(*Conotrachelus nenuphar* Hbst.)

This insect is one of our few serious pests found native to America and was one of the first to be written about and recommendations made for control.

So far as known it does not occur west of the Cascade mountains and we hope that this barrier will continue to be as effective in the future as it has been in the past. The original food plants seem to be plums and wild crab apples. At the present time, in addition to these fruits, cultivated peaches, plums, cherries, apricots, apples, pears, etc., are attacked.

Plate XII.



THE MEDITERRANEAN FRUIT FLY.

1, Larva; 2, Egg; 3, 4, 5, Adult fly and wing; 6, Tip abdomen showing ovipositor.
(After C. W. Mally.)

The main injury to the fruit is caused by the egg and feeding punctures made by the adults (see Fig. 35) and the work of the larvae in the fruit.

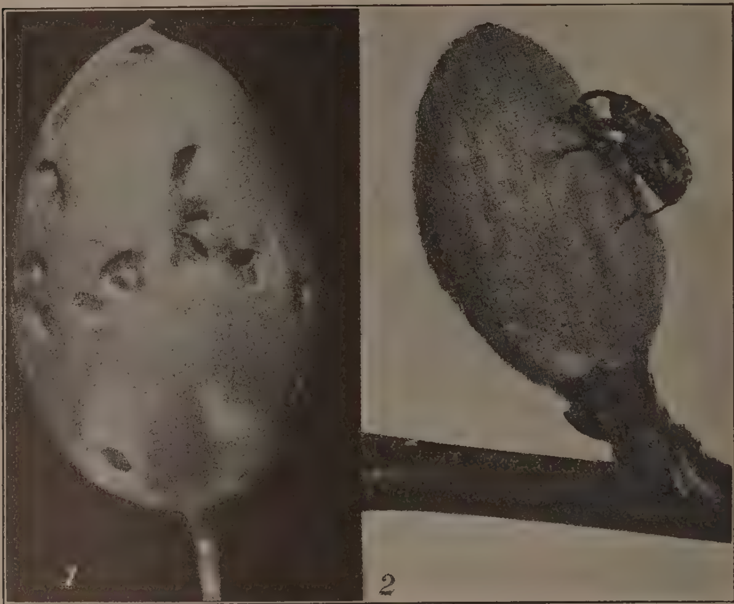


Fig. 35. The Plum Curculio: 1, Young plum with egg punctures; 2, Adult Beetle on young peach. (After Quaintance.)

Life History.—The insect hibernates through the winter as an adult under boards and trash on the ground and comes out in the spring about the time the buds are swelling and begins feeding and depositing eggs in the fruit as soon as it is well set. Egg laying may continue for several weeks and the eggs hatch in from three to six days, depending upon the temperature. The young larva bores into the fruit and feeds around the center until mature, when it crawls to the ground and enters the soil to a depth of several inches, where it pupates. The larval stage lasts from two to three weeks and the pupal stage from two to more weeks. The complete development from egg to adult thus lasts about five or six weeks. After emergence the beetles feed on the leaves and fruit until fall, when they enter hibernation and come out in the spring as indicated.

Remedies.—A combination of clean culture and the application of arsenical sprays thoroughly applied are satisfactory in keeping this insect under control.

THE COLORADO POTATO BEETLE.

(Leptinotarsa decemlineata Say.)

This insect is fortunately so far not known to be present in Oregon. That this condition of freedom can long exist seems rather doubtful. There is practically no one interested in potato culture but what knows the vivid examples we have had in the middle west of what this pest is capable of doing. A brief description of the insect is therefore in place so that we may recognize the pest when it does come and also in order that we become not unduly alarmed

of some pest at present with us because of its real or fancied resemblance to the potato bug.

Fig. 36. The Colorado Potato Beetle: Section of potato plant showing beetle at work; a, Beetle; b, b, Egg masses; c, c, Half-grown larvae; d, d, Mature larvae.
(After Chittenden.)

Description.—The adult beetle is of a very robust form. About three-eighths of an inch in length and a little more than half as wide. It is of a dusky yellow color, the wing covers marked with ten longitudinal black stripes. The larvae resemble slugs, but have only three pairs of legs located on the three segments just back of the head. They are of a dark venetian red, soft in texture and are slimy disgusting looking creatures. The pupal stage is passed in the soil. The pupa is about the color of the larva but shows the forming legs, wings, etc. The eggs are a lemon yellow and are laid in masses on the leaf, usually on the under side near the mid-rib, they are also deposited on straws, dried roots, etc., which protrude above the ground.

Both the adult beetles and the larvae feed voraceously on the foliage of the potato. The beetle is a fairly strong flier and on warm sunshiny days often takes wing and flies about. The insect passes the winter as an adult beetle, usually hibernating in the soil or in a very well protected spot. They emerge in very early spring and feed on any of the Solanaceae that are handy. They deposit eggs on their host, but this egg-laying extends over a considerable period of time, the beetles depositing more eggs whenever they migrate to a new host. There are ordinarily two broods during each season.

Remedies.—Where this insect is very bad no remedy will prove entirely efficient, but the arsenical sprays are the standard solution for their control.

climbing them and eating the buds and stripping away the leaves. Dr. C. Hart Merriam, of the United States Biological Survey, is authority for the statement that ground squirrels are good to eat and were at one time regularly sold in the markets of San Francisco. He also states that thay are much prized as food by the Indians.

Methods of Destruction.—Traps may be used with good success and the Washington Experiment Station states that they have found this to be the most desirable method of getting rid of them. Ordinary steel traps No. 0 or No. 1 placed unbaited and as far down in the burrow as the chains will permit.

Poisoning.—The following formula is recommended by Mr. Merriam. "Strychnia sulphate 1 oz., borax 2 ozs., crushed wheat, rolled oats, acorn meal or corn meal 20 pounds. Dissolve the strychnine and borax in 2 quarts of hot water in a closed vessel, stirring occasionally for 20 minutes or until completely dissolved. Then add 4 quarts warm water (in which one-fourth pound of honey may be dissolved) and sprinkle the solution over the crushed grain or meal, stirring or mixing thoroughly until absorbed. Half a teaspoonful of this should be placed at the entrance of each occupied burrow." Cut pieces of carrot and sugar beet or other vegetable into which strychnine crystals have been inserted are effective. Prunes and raisins so treated have been recommended by several orchardists in this state.

Crude Bisulphide of Carbon may be used to a good advantage where the animals are thick, two persons working together can cover considerable ground in a day and destroy many squirrels, it should only be placed in burrows where squirrels have been seen to enter, otherwise many empty burrows may be treated which is a waste of time and materials. Using pieces of horse manure, corn cobs, lumps of earth or other absorbent material, pour about a tablespoonful of carbon bisulphide on each piece and throw them as far down the burrow as possible; immediately close the opening. This is best done just after a rain as the water in the ground tends to keep the gas in the burrow.

Shooting is decidedly effective and affords amusement for resting hours.

FIELD MICE.

Perhaps these little animals cause far more damage than they are accused of, as they are directly responsible for a great deal of the damage which is ordinarily laid to moles and shrews.

The quantity of green vegetation eaten by a single adult field mouse in the course of a year has been calculated at from 24 to 36 pounds, and on that estimate a thousand would require twelve tons of grass or other vegetation to maintain them for a year.

Methods of Destruction.—"Thorough cultivation of fields tends to keep down the number of mice. Cultivation implies the destruction of weeds and all the annual growths that provide winter shelter for the animals. The mere plowing of a field badly infested with mice is sufficient to drive out most of them. * * * While a high state of tillage does not always bring immunity from mice, it does much to lessen the danger of attacks from them.

"All things considered, strychnine is the most satisfactory poison for field mice. Although a deadly substance, it is less dangerous to handle than either phosphorus or potassium cyanide. For poisoning field mice various baits may be used, such as wheat, oatmeal, or corn. * * * The bait should be soaked over night in a poison syrup, which may be prepared as follows: Dissolve an ounce of strychnia sulphate in a pint of boiling water, adding a pint of thick syrup and stir thoroughly. The prepared syrup may be scented with a few drops of oil of anise. * * * The above quantity is enough to poison a half bushel of wheat or corn, but smaller proportional quantities of grain or syrup may be prepared as needed. After thoroughly mixing the solution if it is too wet a little dry corn meal will take up the excessive moisture. If the solution is not sufficient to wet the grain thoroughly add a little water. * * * Because of the danger of destroying native birds, such as quail, sparrows, and others, the poisoned bait should not be placed in exposed situations, but under shelters which will admit mice but exclude birds. Wide boards lying upon thin cross pieces of wood are excellent for this purpose."

Report

OF

Department of Botany and Plant Pathology

INTRODUCTION

The Department of Botany and Plant Pathology has been enabled materially to increase its equipment and facilities for investigational work during the past two years on account of the increased funds provided in Senate Bill No. 31, 1911.

The equipment of the Department is now thoroughly modern, the library has been materially enlarged and new quarters have been provided. Two assistants have been added to the staff, thus enabling the Department to extend its efforts toward the solution of plant disease problems. The funds allotted to the Department have been utilized to supplement work previously begun, and to begin the investigation of certain of the more important plant diseases, for which funds have not previously been available.

The present report consists of three papers, the first two of which are preliminary reports on the investigation of "Apple Tree Anthracnose" and "Cherry Gummosis," which were originally begun as Adams Fund projects, and have been continued during the past two years with supplementary funds provided under the "Crop Pest" Act mentioned above.

The third paper is entitled "Some Important Plant Diseases of Oregon," and consists of a general account of the more important diseases occurring in the State. This paper is the result of general survey work and embodies the observations of the staff of the Department and the results of minor investigations and experimental work together with the accumulated results of other workers.

The Department is conducting investigations on a number of other plant disease problems, the results of which are not yet ready for publication. These include studies of certain phases of winter injury in fruit trees, together with associated canker diseases, investigations of potato and other vegetable diseases, the mushroom root rot of fruit trees and fruit spots and rots. Some of the diseases are new to science and reports will be made as rapidly as the progress of the investigation will warrant.

H. S. JACKSON.

APPLE TREE ANTHRACNOSE.

A Preliminary Report.

By H. S. JACKSON.

The apple tree anthracnose is, with the possible exception of the apple scab, the most serious fungus disease with which apple growers in the northwest have to deal. In general, the disease is characterized by the formation of dark colored sunken cankers in the bark of the younger branches. These are most abundant on branches under two or three inches in diameter, but are not uncommonly found on branches of larger size.

When they occur on older branches having a thick bark, the cankers may not always penetrate entirely to the wood. Usually, however, the bark in the mature cankers is found to be entirely dead, the cambium destroyed and the sap wood discolored to a limited extent.

Development of the Cankers.

By close observation one may find the young cankers beginning to develop most commonly early in November. The time when the cankers start doubtless varies greatly with the season. It is possible that in seasons of early fall rain they may begin to appear much earlier.

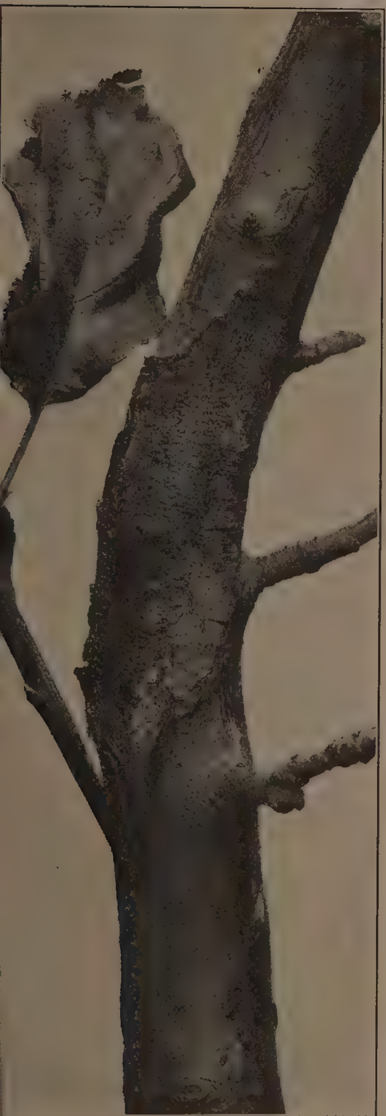
They begin their development as small reddish brown spots in the bark. These when first observed are circular and about one-half inch in diameter and are not sunken. If one cuts into the bark beneath one of these spots the tissues are found to be discolored and to present a water soaked appearance. The discolored area is found soon to extend to the cambium, where it spreads out and may in some stages of the development of the cankers be more extensive in that region than the discolored area on the surface would indicate. The spots develop very slowly, if at all, during the winter months, but spread quite rapidly during March and April. As they enlarge they gradually become elliptical in outline, the surface becomes flat, then slowly sinks.

Sometimes the bark of developing cankers shows bands of slightly varying color, giving the appearance of concentric zones. This is doubtless due to alternating periods of rapid and slow growth induced by variations in the weather conditions. In early stages of rapidly growing cankers an irregular crack may appear in the bark and drops of fermenting sap may exude.

In the early spring, when the warm weather induces renewed activity in the physiological processes of the tree, the cankers develop rapidly. The bark soon dries and sinks and this condition together with the normal growth in the surrounding healthy bark produces a tension which results in the formation of a crack in the bark at the edge of the canker. The spread of the fungus ceases as soon as the cambium becomes active in the spring.

After the cankers reach the full size, which occurs in early May, further activity is confined to changes which take place in the dead bark within the canker. If a mature canker is examined in midsummer, little elevations in the bark are easily observed. They are at first more or less conical in shape and finally burst the outer layer of the bark exposing a cream colored mass of fungous tissue. These are the fruiting structures of the causal fungus and the spores are produced in them in great abundance.

In late summer or early fall the mature cankers are found in abundance and may be from one-half inch in diameter up to eight to 10 inches long by three to four broad. Frequently large cankered areas may be formed by several smaller ones becoming confluent. Mature cankers have a definite limiting crack separating them from the healthy tissue, there is usually a definite ridge surrounding the canker caused by the slight formation of callus tissue at the edge under the diseased bark. The bark is sunken, dry and dead, and darker in color than healthy bark. Thickly scattered over the surface one finds the little cracks described above which are formed when the fungus bursts forth. These cracks are transverse or triangular, seldom if ever, vertical. Fig. 1 shows a typical canker. In old cankers the fungus tissue exposed



ig. 1. Canker of anthracnose on apple branch. Note pustules of fungus in bark of canker.

Fig. 2. Apple twig girdled by small canker of anthracnose.

by the cracks turns black and the bark gradually becomes loose at the edges and drops out, leaving ugly wounds. Bark may cling in the cankers, however, for at least three winters. The wounds, if not too large, slowly heal over by the formation of callus.

Injury Caused by the Disease.

On account of the nature of the disease it is difficult to estimate the amount of the injury resulting from its ravages. Under ordinary conditions few to many cankers may be found on the branches of the trees in infected orchards. Sometimes twigs are girdled by the formation of a small canker, which extends around the stem as is shown in Fig. 2. Not infrequently larger branches are girdled where several cankers grow together. Sometimes trunks of young trees are girdled in this way.

It is evident that the disease in any degree of severity interferes with the normal function of the bark and so hinders the proper distribution of elaborated food in the tree. Branches are weakened by the presence of the cankers and frequently break when heavily set with fruit. The woolly aphis not uncommonly works under the bark at the edge of cankers and further saps the vitality of the tree and interferes with the normal healing over of cankers. Large cankers heal slowly and the wood may be exposed for considerable periods, thus affording opportunity for the entrance of fungi which cause heart rot.

Distribution.

As a serious orchard disease the apple tree anthracnose is peculiar to the Pacific Northwest. It is known to occur in British Columbia, Washington, Oregon and Idaho. It has not been recorded in California to our knowledge, though it is not improbable that it occurs in the northern counties, since it is common in Jackson and Josephine counties in Oregon. It is most serious in those sections having considerable rainfall west of the Cascade mountains. It is rarely a serious disease in the fruit sections of Eastern Oregon. It has been reported once as far east as Nebraska.

LIFE HISTORY STUDIES.

Results of Previous Investigators.

The apple tree anthracnose has probably occurred in the northwest for many years. It began to attract attention as an orchard trouble of some consequence during the period from 1891 to 1893. The serious nature of the disease was realized at that time and through the efforts of the Boards of Horticulture of Oregon and Washington the services of Professor M. B. Pierce, then of the section of Vegetable Physiology and Pathology of the U. S. Department of Agriculture, and stationed at Santa Anna, Cal., was secured to investigate the trouble. Pierce spent some time in both Oregon and Washington in 1894 and 1895 investigating the disease. As far as the writer has been able to learn no report of the results of his work was ever made. In a report (1) of the secretary of the Washington State Board of Horticulture an extract from a letter by Professor Pierce to the board is quoted as follows:

"As I have already given notice to the associated press, I have found a fungus present in the diseased tissue, which is evidently the main cause of the trouble, if not the only cause. The bark dies with the spread of this fungus in the tissue. I am gathering facts respecting the life history of the organism, and shall be pleased to obtain fresh material from as many places as possible, so as to see if the form is constant in all cases. * * * I would not only be glad to get fresh material from various places, but would like pieces of bark which have died over old scars of last year."

Minto in the report of the secretary in the Fifth Biennial Report of the State Horticultural Board of Oregon is authority for the following statement:

"In a letter to J. M. Wallace, president of Salem Waterworks Company of Salem and manager of the extensive Wallace pear orchard near the city, under the date of April 30, 1896, Professor Pierce says: 'My work in Oregon, and later at this laboratory, has demonstrated one thing beyond a reasonable doubt, namely, that the apple canker so common in Oregon, is a disease due to the action

(1) From Secretary's Report, Second Biennial Report of the State Board of Horticulture, Washington, 1893-1894, p. 69, 1895.

of a parasitic fungus. Inoculation experiments here have reproduced the disease in a typical form in perfectly healthy apple trees. * * * I have * * * found the various spore forms, as well as the tree which probably forms the native host of the parasite in Oregon and Washington.'"

It is quite evident from the above that Pierce recognized the true nature of the disease and evidently isolated the causal fungus, studied it in culture, and produced the disease by inoculation. It is extremely unfortunate that he made no report, as the above quotations would indicate that information was obtained which has never since been corroborated by other investigators—notably, the statement that he had found the native host.

In 1899 following insistent demands upon the Oregon Agricultural Experiment Station for information regarding this disease, Cordley, Entomologist to the Experiment Station, undertook an investigation of this disease. Early in the work he found indications that the disease was caused by a fungus and since facilities at that time were not ideal for investigation work in plant pathology at the Experiment Station, he obtained a leave of absence and carried the problem to the botanical laboratory of Cornell University, and there worked under the direction of Professor G. F. Atkinson. As a result of this investigation Cordley discovered the true cause of the disease which he found to be a previously undescribed fungus. He isolated this fungus, studied it in pure culture and produced typical cankers on apple branches in the laboratory. Under date of January, 1900, he published a short, more or less popular, bulletin (2) giving the results of his investigation and experiments and recommending a method of treatment. In this publication he referred to the causal fungus as *Gloeosporium malicorticis*. No technical description was given, though the disease was fully described in popular language.

Later a more scientific paper was published (3) in which a technical description of the fungus appeared. Detailed description of the methods of work and culture are given, and good illustrations of the fungus and its effects are included. In a foot note it is stated that the manuscript for this article was prepared November, 1899.

In January, 1900, Dr. C. H. Peck (4) described a fungus occurring in apple cankers, which had been sent to him by Mr. R. M. Palmer, of British Columbia, as *Macrophoma curvispora*. This was later determined to be the same fungus as that described by Cordley.

It will be noted that the dates given for the first appearance of the description of *Gloeosporium malicorticis* and *Macrophoma curvispora* are the same, January, 1900. No more exact date for the appearance of either of these publications is given. Since Cordley places the fungus more nearly in the proper genus, the name which he proposes has been in general use and is generally accepted as the authentic one for the fungus causing this disease. Credit is, therefore, due Cordley for the first published account of the nature of the disease and a description and proof of the pathogenisity of the organism causing it.

In 1904 (5) Lawrence, at that time assistant botanist at the Western Washington Experiment Station located at Puyallup, published a detailed account of the apple tree anthracnose under the name of "black spot canker."

In this bulletin Lawrence confirms the work of Cordley in regard to the life history of the fungus and its pathogenisity and describes in detail the development of the canker and records many interesting and important biological phases of the disease. The interesting information that the fungus also causes a rot of stored fruit is given and proven by isolation and inoculation experiments. He also shows by experiment that the fungus is disseminated most commonly by the wind and that it is able to penetrate the bark of branches in the absence of any injury, most commonly through the lenticels. Inoculation experiments on hosts other than the apple are recorded. These are discussed on page 189 of this report.

(2) Cordley, A. B. Apple Tree Anthracnose, A New Fungous Disease. Oregon Exp. Sta., Bull. 60, Jan., 1900.

(3) Cordley, A. B. Some Observations of Apple Tree Anthracnose. Bot. Gaz., Vol. 30, pp. 48-58. July, 1900.

(4) Peck, C. H. Bull. Torrey Bot. Club, 57, p. 21, Jan., 1900.

(5) Lawrence, W. H. Black Spot Canker. Wash. Exp. Sta. Bull. 66, 1904.

Interesting observations of the susceptibility of apple varieties to the attack of this disease are given. The evidence furnished, however, indicates that while certain varieties are generally more susceptible than others, the degree of susceptibility varies greatly in different orchards of the same variety and even in different trees of the same variety in any given orchard. Evidence also points to the fact that there is little relation between the character of the soil and susceptibility to this disease.

In 1906 Cordley (6) again published a popular paper on this disease, in which a general account of the information available regarding the disease at that time was given.

In this paper also a record of field inoculation work is given in which 20 young trees were inoculated with pure cultures of the fungus isolated from cankers on the apple. All of the inoculations produced cankers. It is stated that these experiments were repeated many times with favorable results.

In 1906, on account of the fact that many points regarding the life history of the disease had not been thoroughly worked out, the Oregon Agricultural Experiment Station, under the direction of Professor Cordley, undertook a detailed investigation of the life history and method of control of this disease as a project for investigation under the Adams act.

Mr. C. C. Cate, a graduate student in the Department of Entomology and Pathology, was detailed to carry on the investigation. Mr. Cate made a thorough orchard survey of the disease in various parts of the state in an attempt to determine whether any information could be obtained regarding the susceptibility of varieties and whether the condition of the soil had anything to do with the degree of susceptibility. In 1908 a popular report (7) of some of the results of these investigations was published.

The following quotations indicate some of the results of the investigations regarding the susceptibility of varieties and relation of soil conditions to the disease.

"From investigations made during the past summer, it was found that Anthracnose attacks practically all varieties of apples, although some are more susceptible than others. Those most susceptible are Baldwins, Spitz and Jonathans; next are Newtowns, Greening, Gravenstein and most of the summer varieties, while those attacked only slightly are the Ben Davis, Northern Spy, Winesap and Blacktwig. No varieties seem to be entirely immune and occasionally some of the least susceptible varieties are nearly or entirely ruined by the disease. In the varieties like Baldwin and Spitz, the cankers are of all sizes and most of them extend very deep and hence greater damage is done, while on the Ben Davis cankers or wounds are smaller and more superficial, hence very little damage is done to trees of this nature."

"From investigations made this past season, however, it is evident that soil conditions have very little influence upon the disease, and it was found to do just as much injury when once started upon high or well drained soil as any other. And the nature of the soil, whether clay, dobe, loam, granite, or other kinds, had very little if anything to do with anthracnose. For instance, out of 140 orchards visited in the Willamette Valley, only 12 were found that were free of anthracnose and these were either very young or isolated from the main public highways to such an extent that the disease had not found its way into them."

Though Cate was detailed only to carry on field investigations he became interested in the life history of the disease and at odd moments carried on culture work and inoculation experiments. No published report of this investigation was ever made, except a statement in the above mentioned article quoted on page 189 of this report. From an oral report and from notes and photographs on file in the laboratories of the Department of Plant Pathology, it is evident that a large part of the work of previous investigators was repeated by Mr. Cate. The fungus was repeatedly isolated, studied in pure culture and the disease produced by inoculation on apple branches and fruit. Very interesting and important results were obtained regarding the occurrence of the disease on other hosts both from field observations and from inoculation experiments. These results are given in full on page 189 of this report.

(6) Cordley, A. B. Apple Tree Anthracnose. Better Fruit. Volume I, No. 5. November, 1906.

(7) Cate, C. C. Apple Tree Anthracnose. Oregon Countryman, Vol. I, No. 2, pp. 16-19, October, 1908; Vol. I, No. 3, pp. 9-11, November, 1908.

Summary of Results of Previous Investigations.

A close study of the work of the investigations mentioned above regarding the disease of the apple under discussion, shows that the information available previous to 1909 may be briefly summarized as follows:

As affecting the apple, the anthracnose is a fungous disease which attacks the branches and twigs primarily and causes cankers or dead spots in the bark. It is also known to attack the fruit, causing a rot in storage. The cause of the disease is a fungus belonging to the group *Fungi Imperfecti*, known as *Gloeosporium malicorticis* Cordley. Acervuli typical of *Gloeosporium* or *Myxosporium* are produced in the dead bark of mature cankers or in the rotted spots on the fruit. The spores are borne on branched conidiophores and are characteristically sickle shaped. The fungus has been repeatedly isolated in pure culture and the germination of the spores and characters of growth have been studied. Secondary spores are commonly produced on the mycelium in culture.

Pure cultures have been repeatedly used to inoculate healthy trees and the characteristic cankers produced.

Natural infection for this disease occurs most commonly in the fall and many cases doubtless start in wounds but may take place through the unbroken epidermis of branches or fruit. The cankers develop slowly, killing the bark, and are mature and the spores disseminated about one year after infection. The dead bark gradually drops out, leaving a scar which slowly heals by the formation of callus tissue. It has been thought that the fungus dies after the formation of conidia and that cankers were a source of infection only during the first season.

PREVIOUSLY UNPUBLISHED INVESTIGATIONS. (8)

The writer began a study of this disease in the summer of 1909, which has been continued as time would permit to the present writing. In the course of this study many of the results of previous workers have been confirmed and some important points added to our knowledge of the life history of the causal fungus. Much of the work is unfinished and a full report is reserved for a later date. At the present time only the results of our study of certain phases of the life history will be given.

Early in the work a search was made for a possible ascogenous stage in the life history of the fungus. In November, 1909, while studying the characters of "two year old" cankers, that is, cankers resulting from infection in the fall of 1907, the apothecia of a discomycete belonging to the family *Mollisiaceae* were found occupying the position of the acervulus of the previous season (1908). (See Fig. 3A and B.) Careful search revealed the fact that the apothecia of this fungus were nearly always found in the dead bark of cankers one year after the development of the conidial stage. The writer has had this fungus under observation now for three seasons and has never failed to find it in the bark of cankers two years after infection in any orchard in which he has searched at the proper season. No other ascomycete has been found at all constantly associated with the cankers. As noted on page 190, we have also observed the same discomycete in the old bark of cankers on pear trees. Fig. 8C shows an old canker on a pear branch in which it was present.

The ascus spores germinate readily in water or nutrient agar and pure cultures were easily obtained. Great care was necessary in obtaining cultures from ascus spores since it was found that very frequently conidia were developed around the edges of the apothecia from the old acervulus. On this account, as a rule, only those cultures resulting from the germination of the ascus spores, while still retained in the ascus, were used in the investigation. Small bits of the ascogenous layer taken from the center of a well developed apothecium, were crushed in sterile water on a cover glass and then transferred to a tube of sterile water. A small portion of the water containing the asci and spores

(8) At the Washington meeting of the American Phytopathological Society in December 1911, a paper by the writer was read, entitled, "The Development of *Gloeosporium Malicorticis Cordley*." An abstract only, appeared in Phytopathology, Vol. II, No. 2. p. 95, April, 1912.

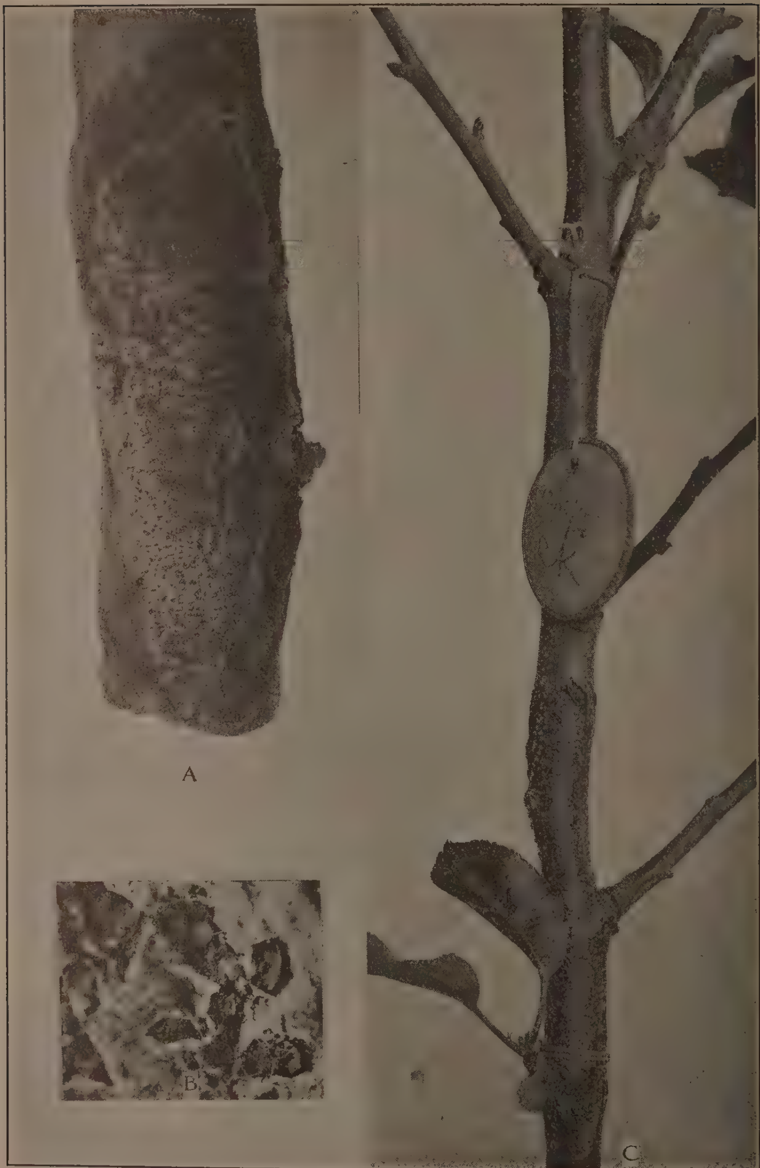


Fig. 3. A. Canker two years after infection showing apothecia of ascosporic stage occupying position of conidial pustules of preceding year.
B. Apothecia in bark enlarged five diameters.
C. Young Spitzenberg apple tree with canker of conidial stage of anthracnose resulting from inoculation with culture from ascosporic stage. Note wound of check puncture at top of figure.

in suspension was used for making dilution plates in the usual way. Carefully filtered agar made with a synthetic nutrient solution was used. The position of asci containing well developed spores was marked on the bottom of the petri dish. These were watched carefully and when germination was well started, were removed together with the smallest possible bits of agar to agar slants. Before removing, the area surrounding the germinating ascus was carefully examined under the microscope for the presence of other germinating spores and sufficient time was always allowed for the germination of any conidial spores that might be in the vicinity. Any doubtful cases were discarded.

Cultures obtained in this way in the fall of 1909 were grown on a great variety of media in an attempt to develop the conidial spores. Sterilized twigs of the apple were also used. Only secondary conidia similar to those discovered by Cordley and Lawrence as occurring on the mycelium of *Gloeosporium malicorticis* were obtained under these artificial conditions. The typical curved conidia so characteristic of *Gloeosporium malicorticis* were never observed, though structures resembling to some extent the acervulus of that species were commonly developed. No inoculation was attempted that season.

In the fall of 1910 fresh cultures were obtained in the manner already described and inoculations made into the fruit of ripe Newtown apples in an effort to obtain the conidial stage which, as described by Lawrence and Cate, and frequently observed by the writer, is quite commonly developed on the fruit, particularly during seasons of early fall rains. In an effort to prevent outside contamination these apples were kept under bell jars in the laboratory and while a rot typical of anthracnose developed and structures resembling acervuli were formed, only secondary spores were produced. This the writer believes was due to the artificial conditions.

On December 12, 1910, 11 young Spitzenberg apple trees were inoculated with bits of mycelium from pure cultures. Seven cultures each having a different origin were used. Five of these cultures were obtained from the germination of spores within the ascus and two from germinating spores which had been ejected from the ascus. The surface of the trees to be inoculated was previously sterilized with corrosive sublimate and a small fragment of mycelium introduced under a slightly raised portion of the outer bark. The points of inoculation were all protected by ordinary grafting wax previously sterilized and applied warm. An equal number of check punctures were made, usually several inches above the inoculations. The same precautions were taken as for the inoculations. The experiment was watched carefully at frequent intervals. About one month after the inoculations were made, spots characteristic of those caused by *Gloeosporium malicorticis* began to appear at the points where the mycelium was introduced and cankers slowly developed after the manner of that disease. No cankers appeared at any of the check punctures. In September, 1911, about nine months after inoculation, mature cankers possessing all the characters of those caused by *Gloeosporium malicorticis* had developed at each of the points of inoculation. Fig. 3C, shows one of the cankers thus formed. The wound caused by the check puncture is shown at the top of the branch. The typical acervuli bearing the characteristic curved spores were abundant in the dead bark of all these cankers. Pure cultures from the germinating conidia of each were obtained, and compared with the lineal descendants of each of the cultures used in the inoculation, and while no extensive physiological study has yet been made, they were found to agree in all characters shown on ordinary culture media.

A complete study of the development of the apothecia has not yet been made, but from data at hand it is evident that the apothecia develop in association with the stroma of pseudoparenchymatous tissue making up the base of the acervulus. After the formation of conidia has ceased the surface of the acervulus usually becomes black, due largely to the collapse of the conidiophores. The apothecia commonly have their origin in a layer just beneath this and at maturity burst forth from it, as shown in Fig. 4C. Sometimes the apothecia are found developing directly over the old stromatic layer of the acervulus as shown in Fig. 4B, and at other times at its margin, as shown in Fig. 4A.

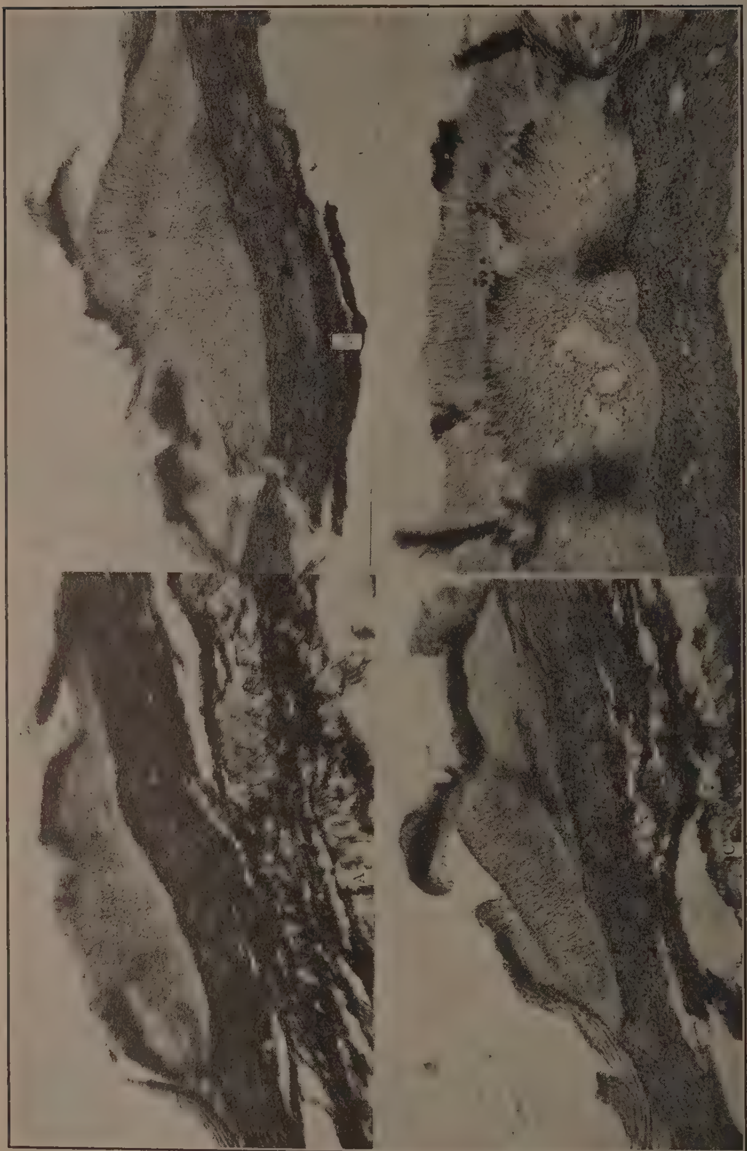


Fig. 4. Microphotographs of development of ascosporic stage of *Gloeosporium malicorticis*. A. Young stage showing two apothecia developing at sides of stroma. B. Later stage of a similar condition. C. Apothecium just breaking open. Lower right hand figure, mature apothecium in position.

Since the acervulus is exposed by the bursting of the periderm in an early stage to enable the conidial spores to be set free, it is seen that the apothecium develops within a more or less *exposed subiculum.*

From an examination of the characters of the genera of the *Mollisiaceae* and related families, the writer has failed to find any genus having those characters. Therefore, the following new genus is proposed for what seems without doubt to be the ascogenous form of *Gloeosporium malicorticis.*

Neofabraea. Nov. Gen.

Characteristics in general, like Pseudopeziza. Apothecia developing in, and at length breaking forth from a more or less exposed subiculum consisting of the old conidial bearing stroma. Spores at first one-celled, at length two- to four-celled.

Neofabraea malicorticis (Cordley) n. comb.

Gloeosporium malicorticis, Cordley, Oregon Agr. Exp. Sta. Bul. 60, Jan., 1900; Bot. Gaz. Vol. 30, pp. 48-58, July, 1900.

Macrophoma curvispora Pk. Bull. Torr. Bot. Club., Vol. 27, Jan., 1900.

Apothecia ½-1. mm. in diameter, light brown in color, waxy, at first concave, then flat and finally convex, surrounded at the edge with the black remains of enveloping layers. Developing within and bursting forth from a subiculum consisting of the old conidial stroma. Asci clavate 90-100 m.m.m. long x 10.5-13 m.m.m. broad, p. sp. 75-80 m.m.m. Spores colorless, one-celled or becoming four-celled on germination 16-19 m.m.m. long by 5-7 m.m.m. broad, elliptical, slightly flattened on one side, developing in a single series. Paraphyses, simple or branched, tips slightly swollen, septate. Developing in the fall on dead bark of Pyrus malus in cankers formed by *Gloeosporium malicorticis* the previous season.

Type locality Corvallis, Oregon.

Since Cordley and Peck described the conidial stage of this fungus at about the same time, there might be some doubt as to the proper specific name. The name proposed by Cordley is used on the grounds that the fungus more properly belongs to *Gloeosporium* than *Macrophoma.*

The apothecia stand out prominently during the rainy weather and tend to disappear during the dry weather, swelling up again with the next rain. On this account the normal production of spores is frequently interfered with and there is a tendency for the spores to become septate and germinate within the ascus, sending threads to the surface of the ascogenous layer and there developing secondary conidia. When the conditions, however, are favorable for any length of time, the asci containing the matured spores elongate and extend for about one-half their length above the surface of the apothecium. The ascus swells and spores collect in the apex and finally are ejected by the ascus bursting and scattering the spores forcibly. This process was observed repeatedly under the microscope and was especially well seen with the use of the Zeiss Binocular. Spores matured in this way do not necessarily become septate on germination.

The resemblance of the life history of the species under discussion to that of *Pseudopeziza ribis* as worked out by Klebahn (9) is most striking, and becomes more so when a comparison of the structures present in the conidial stage of the two species is made. A comparison of Cordley and Klebahn's figures, both of the acervuli and spores would indicate a close relationship between the two species. The most noticeable resemblance between the conidial stage is the characteristic sickle shaped spores. The development of the apothecia, as described by Klebahn, would seem to show that there was no direct relation between the apothecia and conidial bearing layers. In this respect the two forms differ widely.

Economic Importance of Discovery of Perfect Stage.

The economic importance of the investigations by the writer outlined above, lies in the fact that we have proved that the old cankers are a source of infection both on account of the development of the ascospore stage and from the fact noted on page 183 that conidiaspores are also developed from old conidial layers around the edges of the apothecia of the perfect stage. We have also determined that conidia may be developed in the bark of cankers *three years* after infection, but have not found any ascospores in such cankers. It is thus seen that the cankers are a source of infection in many cases through at least three seasons. While a greater part of the study has been with refer-

(9) Klebahn, H. Untersuchungen uber einige Fungi Imperfecti und die Zugehorigen Ascomycetenformen III, Zeit. fur Pflanzenkrankheiten 16: pp. 65-83, 1906.

Fig. 5. Cankers on cherry, prune and pear branches (reading from left to right) produced by inoculation with pure cultures of *Gloeosporium malicorticis*.

ence to the bark left clinging in the cankers, we have also found that when the bark drops out after the first year, as it occasionally does, the apothecia of the perfect stage may be developed in such bark on the ground. The extent of the development of the fungus as a saprophyte in dead bark on the ground has not, however, been thoroughly investigated.

KINDS OF TREES AFFECTED.

The disease was first recorded on the apple and for some time the fact of its occurrence on other hosts was not observed or at least, not recorded.

Lawrence (10) states that——

"Similar canker diseases are found on the alder, cherry, pear, plum, prune and willow. None of these as yet have been proven to be caused by the same fungus as the black spot canker. Those on the cherry, pear, plum and prune probably have the same origin as the one on the apple, as indicated by artificial inoculations. * * *"

In the discussion of inoculation work referred to above Lawrence writes that cankers were produced by inoculation with a pure culture of the fungus causing apple tree anthracnose, on cherry, plum and prune. Development of spores in the cankers thus produced was not observed. He also records having produced the cankers on the trunk and limbs of pear by inoculations from a culture obtained from a diseased apple.

"On the limbs the fungus in all cases penetrated through the bark and into the sap wood beneath. On the trunk it did not enter more than half way through the bark. Pustules and mature spores were found in the cankers on the limbs. No pustules or spores were found in the cankers on the trunk. Spores in these pustules germinated during the third week of May. The cankers on the trunk of the pear, caused by inoculating it with black spot canker fungus are identical with cankers found on the trunks of many pear trees in orchards. Spores have not been collected from the last mentioned cankers. The results of the inoculations indicate that the canker of the pear is also caused by the black spot canker fungus."

Cate (11) made some interesting observations as to the occurrence of the disease on other fruits. He also carried on some inoculation experiments on hosts other than the apple. He says:

"In our investigation we have found it (Apple Tree Anthracnose) upon pear, peach, prune and quince. We have also produced it by inoculation upon the fruit of the apple, and have collected specimens of the fruit of apple and quince with an abundant growth of the fungus on them, with well developed spores."

In the light of observations made since the above report was made, Mr. Cate considers (oral statement) the natural occurrence of *Gloeosporium malicorticis* on peach and prune somewhat doubtful.

From notes and photographs on file in the laboratory of Plant Pathology and from an oral report by Mr. Cate, a more detailed account of his study of the disease on other hosts was obtained. Using cultures of *Gloeosporium malicorticis* carefully isolated from typical cankers on the apple he was able to produce cankers on peach, cherry and prune by inoculation. The left hand and middle branches shown in Fig. 5 give a photographic record of the results of inoculation on cherry and prune, respectively. No record of spores having been produced in these cankers were found. Quite copious gumming accompanied the growth of cankers on peach and cherry. Inoculations were also made upon the pear with the fungus isolated from apple. Cankers more or less typical of apple tree anthracnose were produced, which later formed acervuli and spores. The inoculated branch is shown on the right in Fig. 5. Fig. 6 shows a natural size view of one of the cankers on this branch showing pustules.

A photograph taken by Mr. Cate is on file in the laboratory of the Department of Plant Pathology which shows a canker occurring naturally on the pear which he states (oral report) developed acervuli and spores to all appearances identical with those of *Gloeosporium malicorticis.*

There seems to be no doubt of Mr. Cate's observations as to the occurrence of the disease upon the quince and so far as the writer is aware this is the first record of the occurrence of the disease upon that host. Mr. Cate states that

(10) l. c., 5.
(11) l. c., 7.

Fig. 6. Canker on pear produced by inoculation. Photo by Cate.

it was found abundantly on the fruit (Fig. 7) in the fall of 1908, and he also found small cankers upon the branches in which spores were abundantly produced.

A large series of inoculations with *Gloeosporium malicorticis* was made on various hosts by Mr. Cate in an orchard on the college grounds, but through a misunderstanding the trees were destroyed before a final check could be made and the results of the work were lost.

No effort has been made by the writer up to the present time to make a thorough study of this disease upon other hosts than the apple. In the fall of 1909, however, a rot on quince was observed on several occasions in the vicinity of Corvallis and a fungus identical with *Gloeosporium malicorticis* in all characters noted, was isolated from the tissues. The disease has also been observed on the quince in the orchard during the present season (1912). I am also informed by W. H. Lawrence, now at Hood River, that he has observed the disease on the quince not uncommonly in the Hood River Valley.

In November, 1912, at the writer's suggestion, Mr. H. L. Rees, research assistant in Plant Pathology, made a search for cankers of apple tree anthracnose on pears in the vicinity of an apple orchard seriously affected with the disease near Junction City, Oregon. His search was rewarded by the finding of a number of typical cankers on pear branches as shown in Fig. 8. Spores typical of *Gloeosporium malicorticis* were found abundantly in these cankers. Sufficient time has not intervened to enable us to carry on inoculation experiments, but we feel certain from the evidence presented that the disease occasionally occurs naturally upon the pear. This idea is further substantiated by the occurrence of apothecia of *Neofabraea* in the bark of old cankers on certain of the pear branches collected by Mr. Rees. The morphological characters are identical in all points noted with apothecia as found on the apple.

Fig. 7. Anthracnose on fruit of Quince. Photo by Cate.

On account of the fact that the disease under discussion is

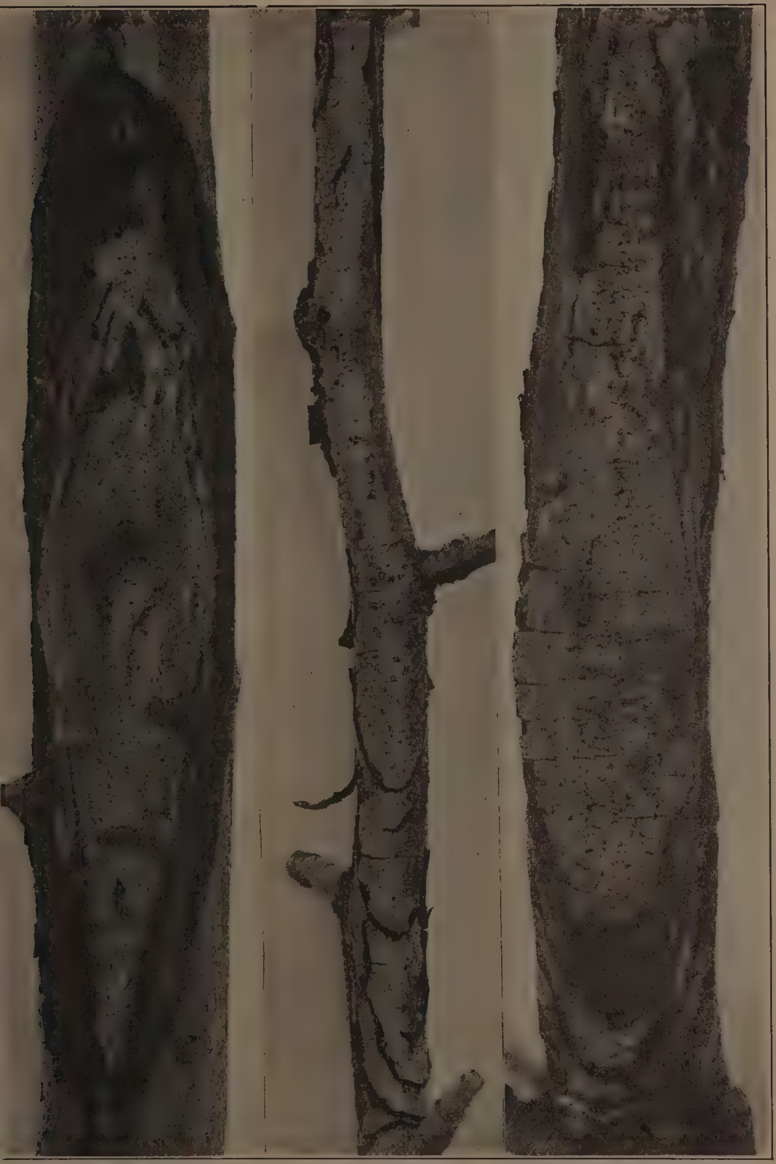


Fig. 8. Cankers of *Gloeosporium malicorticis* on pear branches. The two left hand figures show typical cankers, natural size. The right hand figure shows a two-year-old canker on which occur typical apothecia of the perfect stage.

confined almost entirely to the Pacific Northwest, it has been assumed by a number of investigators that there was a native host on which the fungus occurred previous to the introduction of cultivated fruits, and when the apple was introduced into the Northwest this fungus found it a favorable host for its development. No one has as yet determined what this native host is, at least, no published record has been made. In a quotation given on page 180, Mr. Pierce intimates that he has found this native host. If so, it was unfortunate that the information was not made public. The writer has made no careful search for a native host, but believes that a systematic search would result in its discovery. It is possible that the reason why it has been so long overlooked by those who have searched for it, may be that the fungus as it occurs on its native host produces quite different symptoms than those found on the apple.

DISEASE ON FRUIT.

The apple tree anthracnose is not uncommon as a rot of the fruit as shown in Fig. 9. This may be developed in the orchard, especially if the fruit is allowed to hang late on the trees, or may be developed as a storage rot on fruit which is perfectly sound when stored.

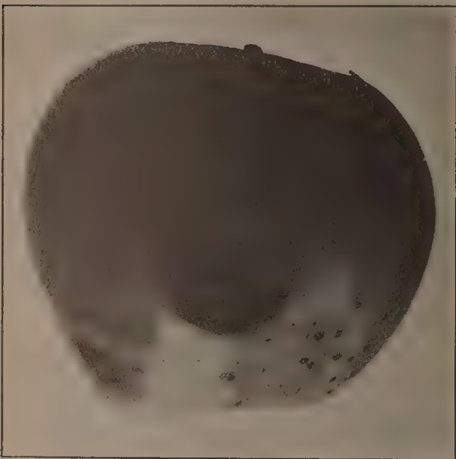


Fig. 9. Anthracnose rot on fruit of Apple.

Lawrence seems to be the first to have recorded this disease as a rot on the fruit. He studied it in some detail, isolated the fungus and produced the disease by inoculation, by placing spores in drops of water on the uninjured epidermis. He also used material from decayed apples to inoculate pear branches with positive results.

Cate also found the disease common upon apple fruit and produced the rot by inoculation. The writer has confirmed the more important results of these investigators and has also produced a rot on the fruit by inoculation with cultures obtained by germination of ascospores. In the season of 1911 this disease developed abundantly and seriously as a rot on stored fruit both under ordinary storage conditions and in cold storage. The writer has seen boxes of Spitzenberg apples kept in storage until May in which 90% of the fruit was affected with this disease. The disease seems to be more abundant on the fruit, as would be expected, in seasons of early fall rain or when on account of weather conditions picking is delayed.

The most obvious line of attack for the control of this trouble on the fruit is to control the disease in the orchard by proper spraying methods. The disease has developed, however, is some cases, in considerable percentage in orchards in which anthracnose was not present or present only in vary slight amount, not sufficiently to account for any large percentage of infected fruit. This has been observed both in Hood River and the Willamette valleys. This fact suggests that a further study of the disease should be made under these conditions in an effort to determine the source of infection and whether or not the fungus may occur as a saprophyte under conditions not at present discovered.

It is possible that infection of the fruit could be prevented by some treatment of the fruit before storing, but no experiments presenting conclusive evidence that this method would be successful have as yet been recorded.

Is the Fungus Perennial?

The idea is held by many growers in Oregon that it is useless to attempt o clean up an old orchard which has become badly affected with this disease. The prevalence of this idea is largely due to the assertions of the late Mr. I. O. Lownsdale that the fungus was perennial in its nature and that new ankers developed from the spread of the fungus in the tissues from old cankers. While we have proven that the fungus is biennial, perhaps to a certain extent erennial in the dead bark of old cankers, we have never found any evidence o indicate that new cankers were formed from the spread of the fungus in he tissues. We have spent some time in a search for evidence to support Ir. Lownsdale's theories. We do find that the fungus penetrates to some xtent into the sap wood and even into the heart wood of affected branches, nd we have obtained pure cultures of the fungus from the heart wood beneath canker of anthracnose two years after the development of the conidial stage r three years from the time of infection. The canker occurred on the trunk f a tree five years old at the time of infection. It is, therefore, possible that he fungus does occur to some extent as a slowly developing rot in the heart ood of apple trees and in this sense is perennial in its nature. This point eeds further investigation. The best evidence, however, against the view hat the fungus breaks out forming new spots from the interior, is that it has een repeatedly shown, as noted below, that old orchards may be cleaned up by roper spraying. It is true that it may take several years to eliminate the isease from an orchard and that its effects will long be evident on account of he cankers on the branches, but if these are properly cared for they will lowly heal over.

METHODS OF TREATMENT RECOMMENDED.

As soon as the nature of the disease and the life history of the fungus ausing it was understood a method of treatment at once suggested itself. s early as 1895 Pierce recognized that spraying in the fall and winter was he logical method of attack. Mr. M. O. Lownsdale (12) is authority for he following statement.

"In June, 1895, Professor Pierce wrote me: 'Yes, I now believe a summer, fall and winter eatment advisable in the first handling of apple canker, which treatments should follow a careful itting out of diseased parts. When the trees have been thus treated one or two years, it will be fe to omit the summer and winter spraying, I think, giving the trees a very thorough treatment ist before the fall rains commence, or as nearly at that time as possible."

In the letter to Mr. J. M. Wallace, quoted on page 180 of this report, ierce further states:

"It has also become evident that the fungus works mostly during the rainy season, and that fection of new trees may take place in the fall and during most, if not quite, all winter. This ows that trees must be treated before the rains begin and often during the winter to prevent fection of new unaffected parts."

On account of the laboratory investigations having been carried on outde the state, Cordley was unable, at the time he first worked out the cause the disease, to carry on any field experiments for its control, but from the e history and knowledge of general conditions he makes the following commendations (13):

"* * * if the trees be thoroughly sprayed with Bordeaux mixture or with the ammoniacal ution of copper carbonate, once soon after the fall rains begin and again as soon after the leaves l as possible, the germination of the spores will be largely prevented and the spread of the disease thereby checked. * * * (For the latter of the two applications mentioned above, Bordeaux xture, winter strength, should be used. For the former Bordeaux, summer strength, may also be d, but if fruit is on the trees it would be better to use the ammoniacal solution of copper carbonate.)
"In addition to the sprayings recommended, we should advise owners of young orchards or hards but little diseased, to carefully cut out and paint over with strong Bordeaux all anthrac-

(12) Lownsdale, M. O. Letter to Editor, Portland Oregonian Dec. 26, 1909.
(13) l. c., 2.

nosed spots that may be observed. * * * For the present at least, * * * it will be advisable to supplement the sprayings by using the knife wherever practicable. Old, badly diseased orchards can best be renovated by pruning severely and spraying thoroughly."

In a later paper Cordley (14), referring to the above recommendation, says:

"I am inclined to believe, however, as a result of later studies that there is no necessity of spraying for this disease before the crop is harvested, particularly if the trees have been sprayed with Bordeaux early in the season for apple scab. I believe now that it is most important to have the trees thoroughly protected by a fungicide during November and December and hence would recommend that a thorough application of Bordeaux be made soon after the fruit is gathered, this to be followed after the leaves are off with another application of Bordeaux or lime-sulphur solution."

The writer (15) has made the following recommendations:

"It has formerly been recommended to spray with Bordeaux mixture or lime-sulphur as soon as the fruit is picked. It has frequently happened that large growers have not been able to spray owing to the fact that by the time the apples were picked the season was so far advanced that on account of the frequency of the rains no opportunity was offered. On this account an experiment was conducted in the Wallace orchard at Salem to test the effect on the fruit of several different strengths of lime-sulphur as well as the Bordeaux mixture and the ammoniacal solution of copper carbonate. The variety sprayed was the Spitzenberg, and it was found that the deposit made on the fruit by the application of spray during the last week in September did not injure the fruit in any way, or seriously interfere with the uniform coloring. Occasionally, however, where the Bordeaux mixture or lime-sulphur collected in drops and made a thick deposit, the color did not develop uniformly, and caused a slightly mottled appearance when the fruit was wiped.

"When for the reasons given above it is considered desirable to spray before the fruit is picked, we feel safe in advising growers to use any of the above mentioned mixtures as late as possible before the first fall rains. The Bordeaux mixture 4-4-50 is to be preferred, since it has been shown to be the best fungicide for this disease. This spraying should be followed by another application as soon as possible after the fruit is picked, using winter strength Bordeaux mixture 6-6-50. In very seriously infested orchards a third application might prove beneficial and should be applied about two to three weeks after the second. Badly affected branches should be pruned out preceding the fall spraying.

"The method outlined above is especially recommended for the purpose of cleaning up an orchard that has become badly infested. Under ordinary conditions when anthracnose is not abundant or when an orchard is sprayed merely for the purpose of preventing the disease from obtaining a foothold, the last two applications are usually sufficient. Good results have been obtained by the use of one annual application of Bordeaux mixture as soon as possible after the fruit is picked.

"Where practical the cankers may be cut out before fully formed during the winter or early spring. To do this it is only necessary to shave off the outer bark. The tissues will then dry out, the trees throw off the disease and the production of spores will be prevented. This method is especially recommended for young orchards where all parts of the tree may be reached from the ground. It is also advisable where practical to cut out the dead bark of old cankers, making a clean wound. The exposed wood should be painted."

RESULTS OF SPRAYING [EXPERIMENTS.

Following the recommendations made by various investigators, many growers have reported excellent results in combatting this disease and in cleaning up orchards badly infected. In the eighth biennial report of the Board of Horticulture of the State of Oregon, A. H. Carson, commissioner of the Third Horticultural District, reports satisfactory results in treating this disease following A. B. Cordley's recommendation as given above. He writes:

"Eisman Brothers own an apple orchard of 35 acres near Grants Pass, which, in 1901, was so badly diseased with anthracnose that they were about to dig it up. Every tree in the orchard was diseased with the fungus. Nearly half of the tops of the trees were dead or dying. The vitality of the orchard was so low that it did not produce apples enough to pay expenses. The brothers worked faithfully cutting out dead spots and dead wood during early spring months, but the fungus continued to increase.

"At my suggestion Eisman Brothers began spraying with Bordeaux early in the fall before the leaves were off the trees, as suggested in Prof. Cordley's bulletin.

"The benefits of their first fall spraying were very pronounced. The spring following showed but very little new tissue affected with the fungus. It was evident the early fall spraying had caught the spores of the fungus as they began germinating and destroyed them.

"Eisman Brothers followed up their spraying in the fall of 1902-3, and today their orchard is very vigorous and free from the fungus."

Many other records might be given to show that apple tree anthracnose may be controlled by following the recommendations given above, but space will not permit of a lengthy discussion.

Several experiments comparing the use of Bordeaux mixture with the lime-sulphur, winter strength, for the control of the disease, have been con-

(14) l. c., 6.

(15) Jackson, H. S. Apple Tree Anthracnose. Oregon Agr. Exp. Sta. Cir. 17, Sept., 1911.

ducted at various times during the past few years, but the general results, as observed by the writer and reported by growers, indicate that Bordeaux mixture is much the better spray for this disease. Mr. C. A. Park, in an oral report, informs the writer that apple tree anthracnose has, during a period of years, been satisfactorily controlled by the use of Bordeaux mixture, in the Wallace orchard at Salem, of which he is manager. For several years previous to 1909, however, lime-sulphur was used in this orchard as a remedy in place of the Bordeaux. During that period, according to Mr. Park's observation, the disease seemed to increase. In the fall of 1909 the orchard was seriously infected. He attributes this, in part, to the failure of lime-sulphur to satisfactorily control the disease. In the fall of 1909, at the suggestion of the writer, the orchard was sprayed in the last week in September. Several different fungicides were used, including various strengths of lime-sulphur, ammoniacal solution of copper carbonate, and Bordeaux mixture. It was again sprayed after the fruit was picked with Bordeaux mixture and lime-sulphur. The experiment was so planned that the results following the use of all of the solutions used in the first spraying might be compared with those used in the second. None of the sprays was found to cause any serious injury on the fruit, though it was necessary to wipe the fruit on trees sprayed with lime-sulphur and Bordeaux mixture.

On examination the following spring the disease was shown to be materially checked. On all the plots indications pointed strongly to the fact that Bordeaux mixture was the best spray for both applications. On this account in the season of 1911 the orchard was sprayed twice, once in the middle of September and again in October after the fruit was picked, using Bordeaux mixture at both times. In the spring of 1912 an examination showed that the disease had been satisfactorily controlled, there being a very small percentage of new infections. The orchard is now in good condition, as far as the prevalence of anthracnose is concerned.

Difficulties.

Many growers complain that, on account of unfavorable weather conditions which frequently prevail following picking, they are often unable to spray in the fall, as recommended, till too late to be of any value. Others complain that, on account of press of work incident to picking and packing a large crop, even in seasons of favorable weather conditions, they have no time to spray till the proper season is past. For many growers it is frequently impossible, or at least highly undesirable, to spray before the fruit is picked. Many orchardists find it impossible to drive through their orchards when the trees are heavily loaded on account of the large number of necessary props. In many older orchards the trees are set so close that when heavily loaded with fruit it is impossible to drive through the orchard with a spray rig without knocking off considerable quantities of fruit. The necessity for hand wiping fruit when sprayed just previous to picking is objectionable to many growers.

On account of the above mentioned difficulties it would be highly desirable if a spray could be applied in the spring when the buds are swelling, or preferably at the time when recommended for the first scab spray, which would stick to the branches sufficiently to retain the fungicidal properties till the next fall and so protect the trees from infection by the apple tree anthracnose at that time.

No such spray has been sufficiently tested to warrant general recommendation. Good results have been reported following the use of a Petroleum-Bordeaux mixture. Investigations along this line could very profitably be undertaken, and it is the intention of the Department of Plant Pathology to thoroughly test out any sprays which give promise of value for this purpose.

Until it has conclusively been demonstrated that such a spray applied in the spring can be made to answer the purpose of fall spraying, growers are urged to spray every fall that it is possible to do so with Bordeaux mixture, and if for any reason the disease becomes sufficiently abundant in the orchard

Being found not infrequently on trees that are not totally dead, they have been suspected by some of having a hand in extending the diseased condition *Schizophyllum commune*, a species of Polystictus, and another shelf fungus belonging to the genus Polyporus, are common in this state. These are well-known wood-rotting forms, and, while it is doubtful whether they can be blamed for much of our cherry trouble, yet, as possible wound-parasites, they deserve further investigation. The attack of the toadstool fungus, which causes fatal root rot or crown rot of cherry trees, also results in the production of gum from the affected parts. This disease is considered under the general topic of mushroom root rot. (See page 226.)

Bacteria as Disease Producers.

There is a disease described by Aderhold and Ruhland in Europe called the bacterial blight of the cherry. Its attacks have done great damage to young cherries in the nurseries especially. In its effects on the plant it is said to be hardly distinguishable from those produced by the Rhine disease before mentioned. The bark is killed, cankers are formed, and trunk or branches may be girdled and often die in full leaf. Gumming usually, though not always, accompanies the disease. A certain species of bacteria have been isolated from the affected plants and by reinoculation the disease has been reproduced. The name *Bacillus spongiosus* has been given to the causal organism. Brzezinski in France also claims to have found bacteria causing disease in the cherry.

DESCRIPTION OF THE DISEASE IN OREGON.

Since numerous distinctly different troubles of the cherry may be accompanied by gum-production, it is evident that the term "cherry gummosis" should not be applied to any specific disease. In this state, however, most of the growers use this expression to designate any disease of the cherry which may be accompanied by gumming. Cherry gummosis, used in this popular sense, appears in what at first glance seems to be a variety of forms. Closer examination and study shows gradations between most of these types such that it is somewhat difficult to distinguish one from another. The question arises, however, whether in this region the cherry is not subject to more than one distinct and definite trouble, of which gumming is a symptom. This is quite probable, but, on the whole, from a careful study in the field and laboratory, it is the writer's present opinion that at least the greater part of the cherry trouble in this section is due to a single disease. This may prove, however, to be too hasty a conclusion.

The More Serious Phases of the Disease.

The condition most dreaded by growers is that in which the trunk and limbs are affected in a more or less general attack. See Figs. 10A and C. Very great loss arises in this manner among the young orchards and is apparently at its worst the third or fourth year after the trees are set out. There is very often little indication of the presence of the disease until an entire tree, or one or more branches, fail to leaf out in the spring or a sudden wilting down of a part or whole of the tree takes place at almost any time during the active season of the plant. Careful investigation in such cases reveals the fact that the trunk or branches have been previously girdled by the disease. Sometimes this injury seems to occur without gum-flow, but as a rule there is a more or less copious exudation. The amount of gumming seems to bear no exact relation, however, to the extent of injury. Upon cutting into a tree from which a small amount of gum is oozing at a single spot only, especially where this occurs on the upper part of the trunk, one often finds that a very large area of the tree is dead or dying. In many cases, indeed, external examination does not disclose the existence of a diseased condition until it has made considerable progress. In the later stages, however, there is usually no difficulty in detecting the disease on account of the fact that no further growth takes place at the affected region, while the adjacent and still healthy

Fig. 12. Two trees showing the serious effects of the disease on the trunk, crotch and limb-bases, a dangerous condition. This is avoided by limb-grafting upon Mazzard seedlings.

parts add a new layer of wood during the growing season. The dead area then appears flattened, and, the dead bark, since it does not expand, frequently, though not always, splits open. In other words, we have the formation of a canker.

The disease seems in general to be active in its spread during the late winter and early spring and to be more or less inactive during the rest of the year. Upon examining a rapidly spreading and badly affected spot by the removal of the outer hide-like layer of bark, we usually find the center of the area dead and brown down to the wood, which is also dead and discolored. At a little distance away from the dead center, the discoloration does not reach inward as far as the wood, and at the margins of the canker we ordinarily find only the outer layers of the bark (the cortical parenchyma, etc.) affected, while the inner layer of the bark (phloem), the cambium and the wood seem normal in appearance. Where the disease is very active we have a mottled effect sometimes produced by alternate patches of dying and still healthy bark. The affected tissues are often permeated with gum, which frequently collects under the outer skin in the form of gum pockets. Where the pressure is sufficiently great the bark splits and the gum exudes. Often it is forced along under the skin and escapes by a crack or injured spot at some distance from the original seat of the trouble. Although thorough histological studies have not yet been made, it would seem that the disease first attacks the outer cortex and then later involves the phloem and cambium beneath. Above and below diseased spots of any size on the trunk or limbs, it is also common to find short or long streaks of brown color, or a series of such streaks running out into the healthy bark, sometimes to a distance of six inches or more. These usually lie between the phloem and outer cortical layer and cannot be discovered without cutting down to them. Above and below very active cankers the healthy looking bark tissue may be filled with many of these brown streaks, while in other cases but one or two or only a few of them may be present.

When the season for the active spread of the disease is past, the healthy tissues of the tree form a special layer of cells (wound cork) separating the affected tissues from those that are still unaffected, and also surrounding the brown streaks just mentioned. At the edges of the cankers also the formation of callus usually commences, but during the succeeding season the callus tissue may be killed and the canker continue to spread. This is sometimes repeated for several years and may result in final girdling, especially in young trees. Older trees that are well cared for usually keep pace with the cankers and sometimes outgrow them. Where the crotch is attacked, the disease often spreads to the limbs and may girdle them one after another. This condition is feared by growers more than any other, because it is so common and so destructive. See Fig. 12. Gum in crotches is not always an indication of disease, however, since in numerous instances a small amount of gum is produced merely as the result of pressure at the union of the limbs. In such cases there is little or no dead tissue and no spreading to cause alarm.

The More Restricted and Localized Cankers.

In this disease we find, then, certain conditions in which a large part of the tree may be rapidly and often fatally involved in a general attack, and other conditions in which large cankers or dead areas are formed that may girdle trunk or limbs, but the disease does not always appear in such severe forms, and we commonly find small cankers and affected spots that are more restricted and localized appearing on various parts of the tree. Near the center of such spots one usually discovers the remains of a dead bud or spur. Sometimes such a dead bud or spur will be found at one side of the canker but connected with it by a streak of dead tissue. This association of small cankers with dead buds is not universal, but it is so common that it suggests the possibility that the diseased spot had its beginning in the death of the bud or spur. In such cases there is sometimes an abundance of gum production and sometimes little. Often an alarming quantity of gum exudes from a spot

where only a very small amount of tissue is found to be affected. Again, a canker may entirely girdle a branch with very little exudation occurring or none at all.

The Blighting of Buds and Spurs.

There is a very common phase of our cherry trouble which has generally escaped the notice of the growers or has been passed by as unworthy of much attention. This is the blighting of buds and fruit spurs, generally accompanied by gumming, which is present in practically all cherry orchards to a greater or less extent, but is much worse in orchards where trunks and limbs are badly diseased. Old trees and younger trees seem to be equally affected. This trouble is first noticeable early in the spring when some of the buds, which formed normally in the fall, fail to swell and open when the others unfold. See Fig. 13. A drop of gum often appears exuding from the bud or from the affected spurs. See Fig. 14. Sometimes affected buds unfold, but before the blossoms open, wilt down and dry up. Often, however, spurs come into full leaf and set fruit, only to die a week or two later. As far as our observation goes, blighting of this sort does not usually take place during the summer or fall.

Fig. 13. Cherry branches showing blighted spurs failing to develop at blossoming time.

The amount of damage directly produced by this form of disease is not very serious in most cases, but the after-effects are probably much more important than has been supposed. Investigation shows that after a spur or bud has been blighted, a small area of discoloration usually spreads out from its base onto the branch. This is almost always confined at first to the outer layers of the bark. As in the case of larger cankers, a layer of wound cork eventually separates the diseased tissue from the healthy substance of the branch. The following season, however, the diseased area may spread farther from the base of the spur, up and

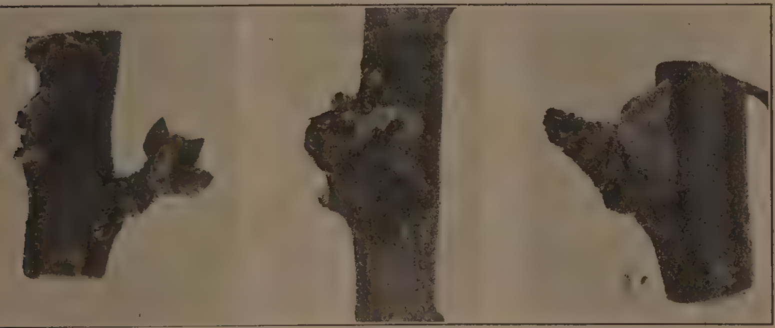


Fig. 14. Examples of spur blight due to bacteria. Drops and masses of gum ooze out from the dead spurs.

down the branch and also, more slowly, around it. The inner parts of the bark and the cambium become affected and a typical canker of small size results. Very often girdling follows and the whole end of a branch may be killed by a canker at its base. Practically all of the dead shoots which so often appear in the top of a tree during the year, seem to be caused by cankers spreading out from spurs or buds that died in some previous season or at the beginning of the same season.

In the case of larger cankers occurring on the trunks and limbs, it is often possible to find dead spurs associated with them. In perhaps the majority of instances, however, it is practically impossible, on account of the age and extent of the affected area, to determine where the starting point might have been. One can go into almost any disease-infested orchard, however, and find a complete series of gradations from the blighted spurs and the little cankers that spread out from their base, to the large cankers that girdle the main limbs and cause bad wounds on the trunks. See Fig. 15. So gradual are the transitions through these forms, and so similar are all the essential features, that it is not difficult to convince a casual observer that they are merely different stages in the progress of the same disease. It remains, however, for careful scientific investigation from all sides of the problem to prove whether or not the connection is more than apparent. This is one of the questions which the writer hopes to solve before the present investigation is completed.

Cherry Gum and Its Formation.

From the preceding discussion it is evident that in the different phases of this cherry disease, the exudation of gum is not an ever-present occurrence. Some of the worst attacks are attended with comparatively little gumming, while sometimes diseased spots of very slight extent yield large quantities of gum. There are also seasonal variations in the amount of gumming which have usually been considered indications of a corresponding variation in the severity of the disease, a deduction which might not always be true. In order to correct any wrong impressions as to the nature of cherry gum and the conditions under which it is formed, an explanation of these points will be briefly given.

The investigations by such authorities as Butler, Sorauer, Mikosch, Bijerinck, Prillieux and others (see appended bibliography on page 217) have established the fact that the cherry gum is formed through the transformation and liquidation of the walls of certain cell tissues. Such tissues are usually formed abnormally by the cambium (the growing layer of the tree) in response to various stimuli produced through the influence of injury, disease, or disturbed physiological conditions. An enzyme is held by many to be responsible for the actual disintegration of the wall substances into gum, though other explanations have been offered. An abundance of water is required in this process and it seems necessary that the tree be in a growing condition in order that tissues susceptible of transformation into gum may be produced.

From these statements one would expect that attacks of the disease, when spreading in the dormant season of the tree, would not be accompanied by fresh gumming. A large amount of gum-production, also, would not be expected where there existed a reduced supply of moisture. In this light, it would seem probable that a tree growing vigorously and having an abundant supply of moisture, even though diseased in only a few small spots, would produce more gum than a badly affected tree which lacked vigor and was exposed to drought. Observation supports these conclusions.

THE EXPERIMENTS OF MR. GRIFFIN.

In March, 1909, Mr. F. L. Griffin found bacteria associated with blighting cherry buds and spurs. Cultures proved these to be so constant in character that the possibility of their being responsible for the blighting was suggested. He then inoculated three normal spurs on a healthy cherry branch; in four or five weeks these were found dead with bacteria present.

In February, 1910, he again took up the work, secured a culture of bacteria

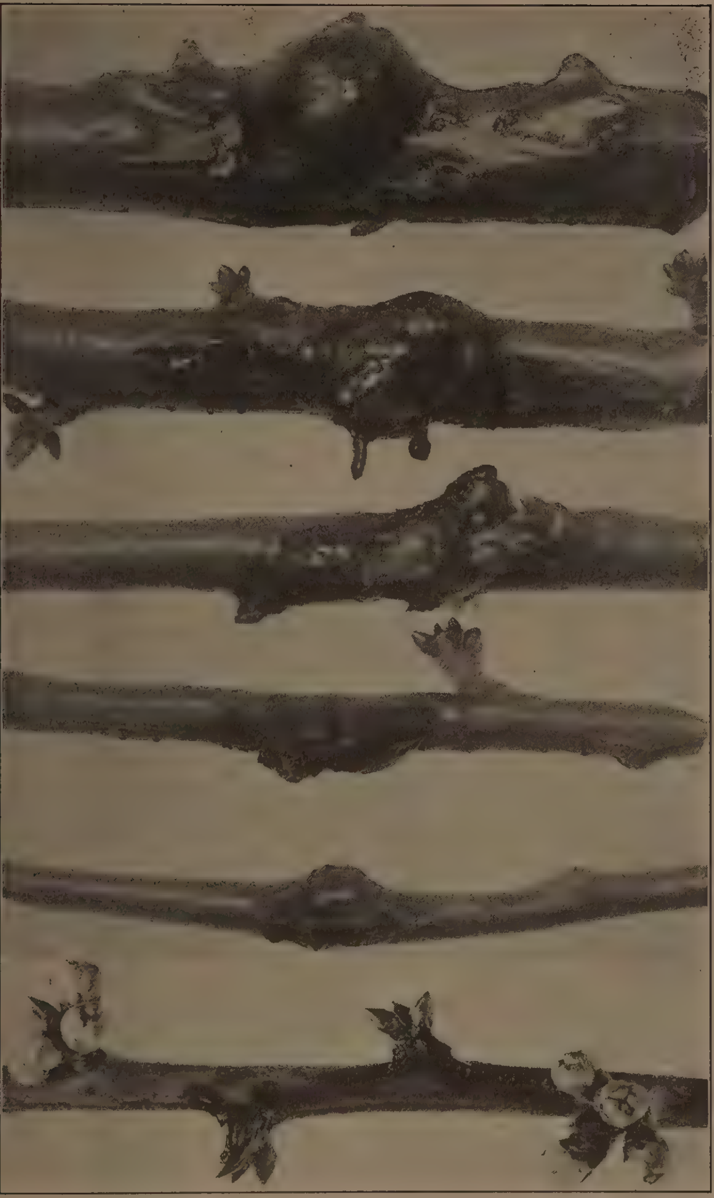


Fig. 15. A series of cherry twigs showing how cankers may develop along the branch, spreading from the base of blighted spurs. A dead bud or spur was found near the middle of each canker. Bacteria like those causing the spur blight are found in the advancing margins of such cankers.

from a blighted spur and inoculated seven apparently normal spurs on a healthy branch, puncturing seven other spurs with sterile needle as checks. In April all inoculated spurs died with gumming—the checks were normal. See Fig. 16A. A pure culture of the bacteria isolated from one of these dead spurs was used to inoculate eight more spurs. Checks were made. All these spurs were blighting by May 8; checks normal.

In the spring of 1911 Mr. Griffin continued the investigation. In March and April he secured from three different sources cherry branches bearing blighted spurs. From at least 19 different spurs he made cultures. These always contained one sort of bacterium either pure or predominating on his plates. In only one case so far as his records show, did he fail to get this organism, and in that case his culture showed no bacteria of any sort. From these cultures he then made a series of inoculations and re-inoculations, a digest of which follows:

Mr. Griffin used the most careful bacteriologic methods in making his isolations, inoculations and cultures, details of which cannot be given here on account of lack of space.

First Series.—From Corvallis. Cultures from four blighted spurs all show characteristic colonies of bacteria. Inoculations made March 25 from one strain into eight healthy spurs produced blighting of all in one month. Checks, with one exception, normal. Cultures from these dead spurs gave characteristic organism in all cases. Strains from three spurs were used for reinoculation on May 15 into healthy spurs. Twenty-six inoculations and checks were made at that time. Two months later 65% of the inoculations were gumming; checks normal. On July 10 cultures of the same three strains were used to inoculate the bodies of two-year-old trees, 28 inoculations and 27 checks. August 1 all inoculations, except one were gumming; only one check seemed affected.

Second Series.—From Salem. Cultures from seven blighted spurs show characteristic bacterial colonies. Three strains used for inoculating healthy spurs April 14. Of 69 inoculations 81% were blighted or gumming six weeks later. Another set of 27 inoculations made at the same time from one of these strains showed, for some reason not apparent, only 30% successful inoculations. Equal numbers of checks were always made. Only three of these were affected. Cultures from the blighted spurs showed bacteria of the usual characteristics. One strain of these was used for reinoculations into the bodies of two-year-old trees on May 27. The 17 inoculations were gumming two months later. Only one of 17 checks showed gum. Fig. 16B is from a photograph of an inoculated tree.

Third Series.—From Eola, Polk county. Cultures from eight spurs showed the characteristic colonies pure. Two isolated strains were used to inoculate 26 spurs and five buds on April 22. Six weeks later all but two spurs were blighted or gumming though the buds did not seem affected. No checks gummed. Cultures from these diseased spurs gave typical colonies like all the rest. One strain was used for making 15 inoculations on the bodies of two-year-old trees on June 22. The last of July found every inoculation gumming. Checks normal. Fig. 16C shows the result of inoculation on one tree.

Pseudomonas cerasus, Griffin, the Cause of Spur Blight.

It can be seen that these results provide rather convincing evidence that bacteria are the cause of the blighting of the spurs and buds. Mr. Griffin made careful morphological, cultural and certain bio-chemical studies of the different strains with which he worked. All the strains proved to be alike. Mr. Griffin compared the characters of this bacterium with that described from the European cherry blight by Aderhold and Ruhland* and found certain differences which led him to conclude that this organism was a new species. He then described it under the name *Pseudomonas cerasus*.

*Because no reference to the morphological or cultural characters of the bacteria discovered by Brzezinski on the cherry could be found, Mr. Griffin could not determine whether they were like those found by himself or not.

Fig. 16. The results of artificial inoculation with *Ps. cerasus*. (o) indicates an inoculation, (x) a check puncture with sterile needle.
A. Blighting of inoculated spurs. Checks opening normally. B and C. Gum exuding at points of inoculation on the bodies of two-year-old trees. The check punctures healed.

This organism, then, seems to be the cause of one form of cherry gummosis. How much it has to do with other phases of the disease only further investigation can show.

Since the only important published reference to this bacterium is in the article by Mr. Griffin appearing in Science†, where only a brief description of the organism is given, it seems fitting that we should devote space here to a somewhat fuller description taken entirely from the bacteriologic chart appended to Mr. Griffin's thesis, in which the various characters that were determined in his study of the bacterium are given. So far this season no work has been done to verify his description. This will be done, however, in the next few months, when bacteria isolated, since Mr. Griffin's departure, from new cases of gummosis will be compared with the original strains.

Pseudomonas cerasus Griffin. Group No. Ps. 211. 2322433 (Soc. Am. Bact.) Causes blighting of fruit spurs in *Prunus avium vars*. In beef broth and upon nutrient agar (+1.0) 48 hours at 30° C., appears as short rods, 1.5 to 2.5, by 0.5 to 0.84 microns, the majority 1.84 by 0.84; ends rounded; on agar hanging drop compact, often in pairs end to end; motile with one or two polar flagella; no spores observed; stains with 1:10 watery fuchsin, gentian violet, carbol-fuchsin and Loeffler's alkaline methylene blue; not acid fast; Gram negative; agar stroke growth moderate, echinulate, flat, glistening, smooth, opaque with greening of medium; decided odor; butyrous consistency; on potato and Loeffler's blood serum same characters as agar stroke without greening of media; agar stab growth best at top, restricted; gelatin stab best at top, liquefaction infundibuliform complete in eight days with greening of medium; in nutrient broth no surface growth, clouding strong, odor decided, scant flaky sediment; prompt coagulum in milk, rapidly peptonized, consistency viscid; litmus milk alkaline, prompt reduction; scanty growth on starch jelly and Fermi; none in Cohn's sol.; copious, viscid in Uschinsky's; growth inhibited by 5% NaCl, HCl+2.2, and NaOH—1.6, optimum reaction+1.5, Fuller's scale; thermal death point 48° C. for 10 min.; maximum temperature for growth 40° C., optimum 25° C.; readily killed by drying, 40% killed by sunlight (15 min.); with sugars no gas production, but produces acid with dextrose, saccharose, lactose, maltose, glycerin, mannit; no ammonia produced, no reduction of nitrates.

RECENT EXPERIMENTS AND OBSERVATIONS.

In February, 1912, the writer began his investigation of cherry gummosis and since that time has confirmed many of Mr. Griffin's previous observations and conclusions. In addition to a study of the blighting spurs and buds, he has also begun to investigate the more serious cankers on limbs and trunks to determine, if possible, whether a parasitic organism is responsible for their development or not. The work can be considered hardly begun, but some points of interest already discovered may be worth mentioning in this preliminary report.

The writer first made use of a culture of *Ps. cerasus*, descendant of a strain of bacteria isolated in 1911 by Mr. Griffin from a spur that had blighted as a result of artificial inoculation with a pure culture. Inoculations were made on buds, spurs, branches and trunks of susceptible varieties of cherries at different times from March 13 to May 10, 1912. Throughout the investigations it has been our constant practice to make a check puncture for every inoculation puncture. In all, there were 53 inoculations upon nine trees. Blighting or gumming resulted within a month in 47 cases (88.6%). Of the checks only two showed signs of gumming or blighting.

It is to be noted that this strain of bacteria isolated by Mr. Griffin from a diseased spur on April 27, 1911, was able to reproduce the disease when used for inoculation on May 10, 1912, after growing all that time in artificial culture. Moreover, this organism causes gumming upon trunks and branches as well as spurs, no trunk or branch inoculation having failed. The few unsuccessful attempts were all in connection with buds at the ends of small branches, and

†Science, N. S. 34, No. 879, p. 615, Nov. 3, 1911.

it may be that another spring will show results in some cases where gumming is not now evident.

The writer also succeeded in re-isolating *Ps. cerasus* from one of these inoculated spurs and this re-isolated strain produced gumming from eight out of 12 inoculations on three trees, the failures being at the base of new buds. The checks were unaffected.

At various times through the season attempts were made to isolate organisms from diseased spurs, from cankers on branches and from affected places on trunks. Trees from different localities about Corvallis and Salem and of different ages were used. From many cases bacteria were isolated. Most, but not all, resembled Griffin's organism in their appearance upon ordinary culture media. All strains, thus secured, were tested as to whether they could induce gumming or not, by inoculation into healthy trees. Such as did induce gum-formation have been retained for studies into their cultural and bio-chemical characteristics, in the course of which they will be carefully compared with the original strain secured by Mr. Griffin. It is to be understood, therefore, that when a strain is spoken of as similar to Griffin's organism, this similarity is based merely on the appearance of growth upon only two or three kinds of media, it being left for further study to determine whether they are identical or not.

A New Type of Bacteria from Branch Cankers.

Toward the end of March cultures were made from branches brought rom Salem, on which cankers were actively spreading. Four out of eight cultures gave an abundance of bacteria, apparently all alike. See Fig. 17. Cultivated on beef-peptone agar they could not be distinguished from *Ps. cerasus*. Inoculations to the number of 109 were made on spurs, branches, limbs and trunks of two trees. On May 10, 22 more inoculations on six trees were made. Of a total of 131 inoculations, only 87, or about 66%, produced gum and no spurs were found blighted. Few of the checks were affected. When cultivating this strain upon a potato-dextrose agar it was discovered to show entirely different color from Griffin's organism grown on same medium. (This type may be called Type 2 to distinguish it from Type 1, composed of those entirely similar to *Ps. cerasus*.)

Fig. 17. Bacteria which induce gumming of the cherry. Magnified 500 diam.

On April 17 and on May 6, cultures taken from two different trees with affected trunks in a three-year-old orchard at Corvallis, gave abundant colonies of a type like the foregoing. Of 32 inoculations made with these two strains only nine have yet showed any gumming. Checks unaffected. We have secured, then, three strains of bacteria similar to each other, which will produce a certain amount of gumming on the cherry, but which are in some ways unlike *Ps. cerasus* and do not seem to possess equal virulence.

New Isolations of the Ps. cerasus Type.

The other strains of bacteria isolated by the writer which possess the ability to induce gumming are all, as far as can be judged at present, similar to Griffin's organism. This type was isolated more often than any other and inoculations with these strains were successful in a high percentage of cases.

From Blighted Buds and Spurs.—On April 16 cultures from a blighted bud and a gummed spur gave abundant colonies of Type 1. On May 17 a blighted spur gave similar colonies, as did also a spur-culture of July 3. Inoculations to the number of 36 were made on the trunks and branches of 10 young trees on May 10 from the first two strains. Of these, 32 were successful. Checks normal. Inoculations with the others were made in midsummer and the results are negative, doubtless because of the lateness of the season.

From Branch and Limb Cankers.—The *Ps. cerasus* type was predominant in isolations from the branch and limb cankers. Five different isolations

from such sources showed abundance of these bacteria. Out of 65 inoculations, on trunks and branches of 17 trees using the first four strains, 51 later showed gum. The failures were all on the youngest twigs. Checks normal. Inoculations with the other strain were made too late for good results.

From Diseased Trunks.—From trunks affected with gummosis, bacteria of the type like Mr. Griffin's were secured in the majority of cases. Out of 40 inoculations on trunks and branches of 10 trees with cultures of bacteria isolated from three different diseased trunks, 31 were successful. Failures all on small shoots. Checks normal. Another strain like the rest was secured but inoculations with it were too late for results.

Other bacteria unlike these two types in appearance occasionally occurred in cultures, but saprophytic intruders in the old dead tissue are to be expected. Several of these, used for inoculations, failed to produce the slightest gumming. Cultures from diseased parts did not always show the presence of bacteria. All cultures made during May, however, gave abundant colonies of bacteria, as did nearly all made in April or June. In February all, and in March half, of the attempts to secure organisms failed, while every one of 18 attempts made in July, September and October, were unsuccessful. Attempts to inoculate healthy trees directly from diseased tissues or from fresh gum gave no evident results.

Microscopic Observations.

In examining under the microscope sections of fresh tissues from spreading cankers, the writer has observed, time and again, masses of bacteria occupying spaces in the discolored cortical tissues. He has also found bacteria occupying spaces among the discolored cells which compose the long brown streaks running out from the large cankers into healthy bark. These bacteria have been found frequently at some distance from the centers of disease where the bark is dark or gum-soaked. Investigations into the pathological histology of the disease have just been commenced and will be the subject of later report.

SUMMARY OF EXPERIMENTS AND OBSERVATIONS.

To sum up the result briefly: 1. The experiments of Mr. Griffin and the writer seem to indicate that a species of bacterium *(Ps. cerasus)* is responsible for the blighting and gumming of buds and spurs on common varieties of the sweet cherry. 2. This bacterium is also able to induce gumming when inoculated into the body and branches of these varieties. 3. Bacteria similar to *Ps. cerasus* have been found during the spring in nearly all spreading cankers on the trunks and limbs as well as in diseased spurs, and these, by inoculation into healthy trees, are able to induce gumming. 4. At least one other type of bacteria is not uncommon in gummosis-affected tissues, and these are able to cause gum-production to some extent, at least, by inoculation. 5. From observations made through one season only, it appears that the disease progresses rapidly in the spring and only slowly or not at all during the summer and autumn. 6. It is impossible to state positively from our present knowledge that bacteria are responsible for all the more serious phases of the disease on the body of the tree, or to indicate just what part they play in its spread. The possibility of their being causative agents seems, however, to receive considerable support from the recent investigations, but in view of many uncertainties and because of the small amount of information we have yet obtained regarding the disease, the writer would be unwilling to maintain at present any definite opinion on the subject.

Investigations must be carried on over a number of years before the nature of the disease can be demonstrated beyond a doubt, or recommendations for its control can be made with assurance. The relation which climatic and soil conditions, the attacks of insects or fungi, and the methods of cultivation have to the disease, must be studied thoroughly. This will take time and the cherry grower must not be impatient.

PREVENTION AND CONTROL.

More important in the eyes of the practical orchardist than the cause, is the remedy for the disease. The writer has not had very much opportunity to experiment in methods of prevention and control during the past season, although something has been done. The work in this direction has been largely observing the practices of the most successful cherry growers in certain parts of the state. A set of experiments, however, has been planned for the coming year, from which it is hoped to secure a basis for future recommendations.

Resistant Stocks and Varieties.

The Mazzard Cherry as a Stock.—Attention has been called to the fact that winter injury and unfavorable soil conditions may have a great deal to do with the appearance of gummosis in the cherry. It may be that the more serious phases of the disease cannot occur without a previous injury or weakened vitality due to some such factors. It is well known, both in this country and abroad, that the Black Mazzard cherry, the wild sweet cherry of Europe, is much hardier and less liable to suffer from adverse conditions than are the cultivated varieties. Hence, seedling Mazzards have come to be much used in Europe as stocks upon which to graft the commercial sweet varieties. In this country also the Mazzard is coming to be recognized as a sturdy stock which unites with the sweet cherries better than the Mahaleb. A point in favor of the Mazzard as a stock is that it seldom gums. Mr. Griffin calls attention to this fact in his thesis; and in observing orchards where Mazzard trunks are used, the writer has been convinced of their gummosis-resisting qualities. To make use of Mazzard stock and to graft or bud on the limbs the variety desired, gives trunk, crotch and limb bases that are practically free from trouble. If the disease then appears in the top, it cannot involve the entire tree, and experience seems to show that the branches are much less liable to suffer from gumming when the body of the tree is clean.

The writer was skeptical enough regarding the reputed resistance of the Black Mazzard stock to spend some time during the past summer collecting a few statistics. Some of the results are given here. An orchard of sweet cherries was planted near Salem some years ago. The tops are said to have all died from "gummosis." From the roots there came up shoots that grew into large trees free from the disease and bearing a small, very dark cherry with a plump stone. These were apparently Black Mazzard trees from old Mazzard roots. The writer visited the orchard and found them free from gum or disease. He visited also an orchard of Royal Ann, Bing and Lambert trees, seven or eight years old, which had been limb-grafted onto Mazzard stock, secured largely from sprouts on the old trees above mentioned. Of the 80 trees only nine showed even a small amount of gum on the Mazzard part. The rest were clean bodied. Of those recorded as gumming at all, the great majority showed only a very small amount of old gum. About 320 trees which had also been limb-grafted on Mazzard were examined in an adjacent orchard of the same age. Of these 87% of the bodies and crotches were without gumming. The rest showed only a little gum. On these two farms there were also root-grafted trees that were covered with gum and badly cankered, in striking contrast to the top-grafted ones. Another orchard near Salem, six years old, had a few ordinary nursery stock trees. These were badly affected in trunk and crotch. There were 83 others which had been limb-grafted on supposed Black Mazzard stock; 76 of these had clean trunks and crotches, four had some gum in the crotch, and only three had badly diseased crotches. In another orchard of 460 trees (seven years old) having supposed Mazzard trunks, only 25 trunks were badly affected and 380 were not affected at all. A six-year-old Royal Ann orchard with Royal Ann trunks adjoins the last-mentioned orchard, and of 147 trees examined only nine trunks were free from disease, while 19 were slightly diseased, 50 badly cankered and gummed, and 69 had been cut down or had died, presumably with gummosis. The writer is convinced that the use of the Mazzard as a stock on which to limb-graft or bud the other varieties, is a thoroughly practical way of protecting the

Cutting Out the Disease.

Whatever may be the primary cause of cherry gummosis, the spreading of the injuries is probably due to the presence in the affected parts, of organisms that work out into healthy tissues and cause their death. Be this as it may, the most successful method of treatment in practice among careful cherry raisers consists in the thorough cutting-out early in the season of all diseased, discolored and gum-soaked bark. Persistent watch is kept by frequent inspections and as soon as new diseased spots are discovered, they are cut out. Where this has been conscientiously done, and the injuries have been cut out before getting very large, the recoveries have been rapid and the damage from the disease rather small, as far as the writer's observations have gone. In cutting out, it is important that all the tissues which are in any degree affected should be removed. The wound thus made should be sterilized, preferably by the application of a solution of corrosive sublimate (1-1000); when dry, large wounds should be coated with walnut grafting wax* as a protection against the entrance of destructive wood-rotting fungi. It is often impossible to discover at once all the affected tissue around a gum exudation or canker, and a second or third cutting-out may have to be made during a season, but persistence will be rewarded in most cases by a rapid healing of the wound through the growth of new callus tissue over it. Care should be taken not to remove any more of the living and healthy tissues than is necessary in cutting out the disease. On the edges of cankers it is often not necessary in cutting to go down to the wood and cambium, removal of the outer layers being sufficient.

Where a small branch is affected, it is often better to remove it entirely and allow a healthy one to take its place. In young trees it is strongly recommended to remove all blighted spurs and cut away discolored tissues that spread out from their base; since our investigations lead us to suspect that many of the serious cankers originate in this way. The best way to prevent a possible bad canker on a future limb is to "nip it in the bud."

Spraying seems to be practically useless as a means of control for cherry gummosis. The way in which the disease gets a start is not yet known, but if bacteria are active agents, spraying can be of little or no effect. Slitting of the bark has been recommended by many growers, but we cannot see that much benefit results except where a gum pocket is opened and the gum is prevented by release of pressure from spreading under the bark. On the contrary, where trunks or limbs have been slit deeply, bad wounds are sometimes produced, and instances of apparent spreading of the disease along the slit argue against the practice.

Other recommendations with regard to treating the diseased trees have been made by various growers, but the writer has not yet had opportunity to test them. The cutting out of the cankers, however, has resulted in local benefit in so many well-authenticated instances under the writer's observation, that he does not hesitate to urge growers to adopt this practice. Although it takes time and patience, it pays in the end. The time to begin is when the trees are very young. Small cankers can be easily cut out, but an old tree full of disease is an almost hopeless case to work on.

*The formula for making walnut grafting wax is given in the Oregon Agricultural Experiment Station Bulletin No. 111, p. 96.

SUMMARY OF RECOMMENDATIONS.

1. Use a resistant stock like the Mazzard cherry, and graft or bud into the branches to secure a trunk and crotch practically free from gummosis.
2. The Lambert cherry is recommended as being somewhat more resistant to the disease than the Royal Ann and Bing varieties.
3. Good cultivation in the spring is urged as promoting a vigorous and healthy growth and rendering the trees more likely to resist the spread of the malady.
4. The cutting out of diseased tissue and sterilizing of the wound will check the development of cankers in many cases, especially if taken in the earliest stages. New orchards should be carefully inspected for several years and all affected spots treated as soon as discovered.

A Partial List of Important Works Relating to Cherry Gummosis.

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SOME IMPORTANT PLANT DISEASES OF OREGON.

Introduction.

The following series of papers relating to the more important fungus and bacterial diseases of agricultural plants present in the state of Oregon is prepared with the idea in view of giving to the practical man in brief form and, in so far as is possible, in un-technical language, the more important facts concerning the symptoms, cause and control of a few of the more common and serious of these diseases.

Our knowledge concerning the seriousness and distribution in this state of the troubles included here is the result of survey work which has been carried on at odd times, and in connection with general field work, and through correspondence during the past two or three years.

It is not our intention in this account to present the results of original investigations, nor are these papers intended for the use of students or specialists, but we aim to bring together for the benefit of fruit growers and farmers, the information on these subjects which is scattered in publications of all sorts and apply this information to local conditions. Our excuse, if any is needed, is that this information has never before been brought together in available form for the people of the state. The great number of inquiries which come to the office of the Department of Plant Pathology indicate that this information is needed and will be of real aid to the horticulturists and general farmers of Oregon.

It is not the intention to include all the diseases which we know to be present in the state. Only those that are considered of special importance or concerning which we have had many inquiries from growers are included.

The information presented, as above indicated, has been obtained from all available sources, together with observations and minor investigations by the members of the staff of the Department of Plant Pathology. In general, we have not given references for the source of our information, nor cited our authorities, and we wish here to make acknowledgement to all investigators, the results of whose work have been used in this report. The accounts of the diseases of the different crops have been prepared by the various members of the staff of the department, who are individually held responsible for the parts prepared by each.

H. S. J.

CROWN GALL.

By H. P. BARSS.

Crown gall is a very common and widespread disease known under a variety of other names such as "galls," "tumors," "root knot," "crown knot," "woolly knot," "hairy root," etc. It is present in all parts of this state. It has also been reported from every other state in the Union and from Canada, Europe, Africa and Australia as well. It attacks the apple, prune, peach, cherry, raspberry and many other cultivated and wild plants, herbaceous as well as woody. It is very common on members of the rose family (Rosaceae) to which all of our ordinary tree fruits and many of our small fruits belong. Besides the plants above mentioned, it is reported as attacking the grape, walnut, chestnut, poplar, willow and alder. In Oregon it is known on practically all of our tree fruits, is found on blackberries, raspberries, loganberries and grapes. and also on the hop. The usual effect upon these different hosts is the production of tumors or galls, which are in general somewhat similar in form and appearance. The galls, as a rule, have an annual development, that is, they begin to form in the spring as the tree starts active growth and cease development in the fall. At first they are small, nearly spherical masses of more or less succulent tissue, whitish or translucent in appearance but rap-

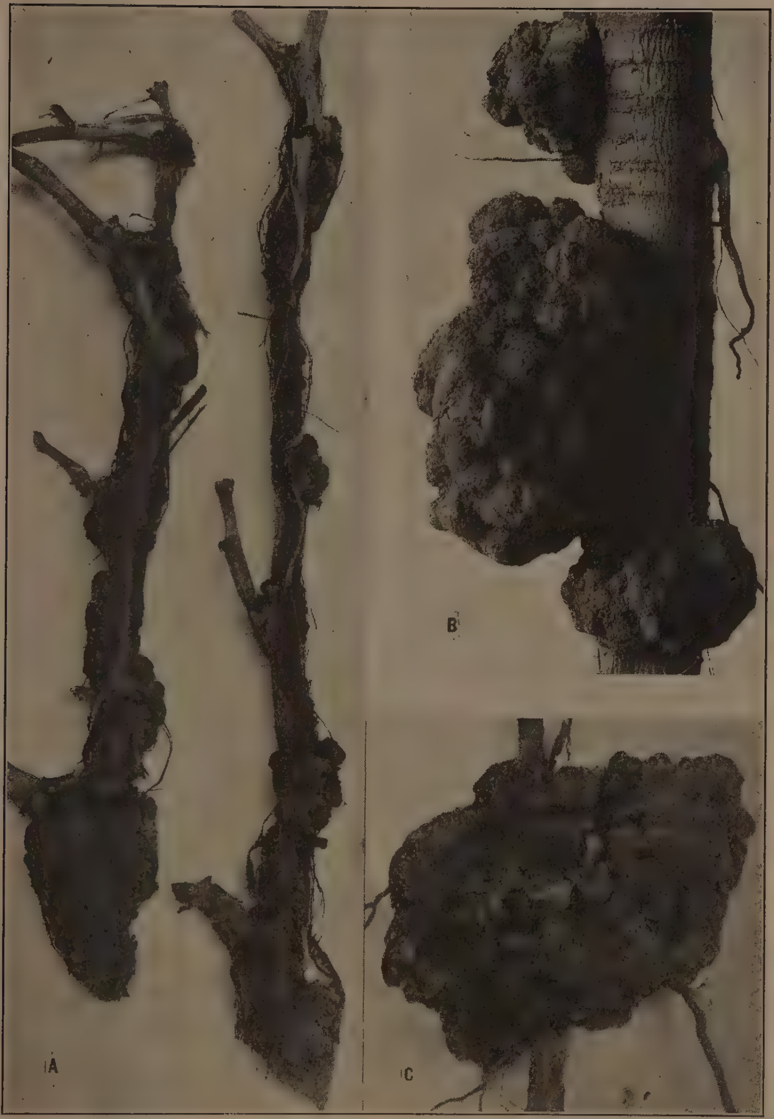

Fig. 20. A. Crown gall on the canes of grape. B. Crown galls on the peach root of a prune tree. C. Crown gall on a loganberry root.

idly becoming darker and uneven, till at maturity they are dark brown and warted. When occurring on small roots they may be only about one-quarter inch in diameter, while on nursery stock, raspberries, etc., they may be about the size of a walnut. On large trees in the orchard they may reach a much greater diameter. The galls usually occur at the base of the trunk or on the roots, though in some plants they are found on the stems or branches above ground. The most common point of attack, however, is just beneath the ground at the crown of the plant. A peculiar form of the disease known as hairy root occurs commonly on the apple.

The effects of an attack of this disease are much more serious on certain kinds of plants than upon others and even among individuals of the same kind there are wide variations in the resulting amount of damage. In some cases trees may be affected without giving any signs of harmful effect upon growth or production of fruit. In other cases, trees or smaller plants are often stunted and unprofitable and not infrequently die as a result of the presence of the galls. There are also many well-authenticated instances where trees known to be badly affected with crown gall have experienced apparently complete recovery. Furthermore, some of the serious ill effects attributed to this disease must often, on careful investigation, be charged to other troubles which have had entrance through the unprotected or decayed gall. The fire blight bacteria, mushroom root rot, wound parasites and heart rot fungi of various sorts as well as certain insects have easy access to a tree through galls where a healthy bark would have prevented any attack, and in most cases these secondary intruders are liable to have more serious consequences for the tree than the mere presence of the gall. It is supposed also that the disease may appear in severe or in light form, depending upon the virulence of the strain of organism producing the infection.

The detrimental effect of the crown gall itself may arise in several ways. The tumors rob the plant of some nutriment. Excessive evaporation of moisture may occur from the unprotected gall surfaces, especially where aerial galls are abundant on slender stems. The galls may also interfere with sap-flow and the decay of soft galls usually involves adjacent healthy tissues producing serious wounds or in some cases girdling the stem with death of the plant as a result. One of the worst effects of the disease is the frequent prevention of normal root development resulting in the failure of a young tree to establish itself or in the retarding of its growth.

Cause.—Crown gall has been known and recognized as a serious disease for many years. Until comparatively recently, however, the cause was unknown. As soon as experimental investigation was taken up, however, the infectious nature of the disease became apparent, and a search was made for the causal organism. The careful experiments begun in 1904 by Smith, Brown and Townsend, of the United States Bureau of Plant Industry, have proved conclusively that the disease is caused by a bacterium. This germ was first isolated by them from tumors on Paris daisy plants and was described in 1907 under the name *Bacterium tumefaciens*. Since that time continued investigations have proved that galls formed in nature on a great variety of trees and smaller plants are caused by this particular bacterium or by slightly different varieties of the same.

The bacterium causing crown gall is an organism which can exist in the soil. It seems to be widely scattered in many soils, but appears especially abundant in nurseries and in land where plants affected with crown gall have previously been grown. The exact manner of natural infection has not been definitely established. Plants in a young, tender and rapidly growing condition, however, are most subject to infection, whereas older and more mature plants are not so frequently attacked. The wounds made in root-grafting and budding offer a favorable point of entrance for the germs, and injuries to the underground parts of plants by cultivation, attacks of borers, etc., render them susceptible to infection. In fact, the organism may be considered a wound parasite.

The Effect of the Organism.—In order to cause infection the bacteria must enter into some part of the plant where new cells are in the process of

formation. They make their way into the living cells and stimulate them to abnormal and very rapid multiplication. Cells near those containing bacteria may perhaps be stimulated in the same way. The number of bacteria in any one cell is not large. They multiply slowly and do not appear to injure the cell to any great extent, but merely to stimulate rapid division. When a cell containing bacteria divides into two, each of the daughter cells contains some of the bacteria and hence will be stimulated to rapid multiplication. Thus, as a result of the presence of the bacteria, there is formed an abnormal mass of rapidly growing tissue in which the elements become distorted and twisted. It is an unnatural, wasting growth, in no way adapted to the needs of the plant. Such galls or tumors vary greatly in form, size and consistency, depending apparently upon the virulence of the particular germ causing the infection, the kind of plant or variety which has been attacked, the particular tissues which were first infected, etc. Even individual plants of the same variety show great differences in susceptibility to this disease.

The Soft Gall.—One of the commonest forms of crown gall especially on herbaceous plants and cane fruits, is the fleshy form in which the outgrowth is somewhat soft. These grow rapidly and are not protected by a bark or corky layer. Growth usually commences in the spring (sometimes earlier). After a few months of development the outer layers of the gall begin to die and are attacked by various bacteria and fungi. This generally ends in the decay and sloughing off of nearly the whole tumor by the end of the season. The margin of the gall, however, usually remains alive and during the next season the tumors grow out again, followed as before by decay. When the gall dies some of the healthy substance of the plant is usually killed and a wound is formed which renders the entrance of other diseases easy. Galls are known to die off completely in some cases at the end of the first or second season, while the plant recovers; but commonly the tumors reappear from year to year.

The Hard Gall.—Not all galls are of this soft type, but many are very hard and woody, in which case the growth is apt to be slower and the gall persists longer—often for many years. The exterior may develop a bark-like covering and instead of a rapid decay at the end of the season, there is often little or no disintegration and the gall increases in size as new growth is added each season. In time, however, the surface of the hard gall usually suffers disintegration to some extent. Between the softest and the hardest galls there are many transitional forms and soft galls often develop a woody structure and become persistent.

Hairy Root.—In the apple, and in some other plants, there is a very common trouble known as hairy root. This is produced by the same organism that causes other forms of crown gall. In typical hairy root there is no large gall formation, but there appear on the main roots or on the crown clusters of numerous, succulent, abnormally fleshy rootlets which generally project nearly at right angles. When dry these rootlets shrink and become hairy in appearance. Bacteria are not found in the abnormal rootlets but in the flattened and often inconspicuous tumor from which they arise. Hairy root is not found to be entirely distinct from other types of crown gall. The tumors on certain plants frequently produce abnormal rootlets and the aerial hard gall of the apple will often develop roots when subjected to moist conditions. Furthermore, the organism isolated from hairy root is capable of inducing the formation of typical galls as well as hairy-root when inoculated into different plants.

Tumor Strands and Secondary Galls.—The interesting discovery has recently been made that in certain plants strands of tumor cells may push out from the primary galls, and working through certain easily penetrated tissues, may reach distant parts where by rapid multiplication of the tumor cells new galls are formed which burst out from the parts of the plant thus invaded. Much of the severe breaking out of galls along the canes of some of our small fruits and of grapes may eventually prove to be secondary growths of this nature.

Modes of Infection.—It seems probable that the disintegration which the crown galls usually undergo sets free the disease-producing bacteria contained in them, and as a result the soil becomes infected. It is common experience that soil infection is responsible for large nursery losses every year. Nursery conditions are particularly favorable to the transmission of the disease. Trees are planted close together. They are in the earliest stages of rapid growth and hence in the most tender and susceptible condition possible. The disease develops principally during the first year or two and is said to gain entrance almost entirely through wounds or as a result of root-grafting or budding. Budded trees are not so liable to infection as grafted trees, while root-grafts made in a careful manner* result in less gall formation than grafts carelessly made. Ground infected by the presence of diseased trees will prove capable of transmitting the disease to young trees set later in the same ground and cultivation spreads the trouble along the rows, while careless cultivation causes wounds which afford opportunity for the entrance of the bacteria. A large amount of infection is also possible where trees are heeled into soil that has previously covered galled nursery stock.

Trees may also become infected from the soil after being set out into the orchard. This frequently occurs with the stone fruits but not very commonly in the case of the apple. Most of the crown gall in our orchards, however, is due to the infection of the trees while in the nursery. There seems to be little evidence that infections spread from one tree to another in most apple orchards. Where berries, however, are set close together, serious spreading of the disease from plant to plant, has sometimes been recorded. The mode of infection resulting in aerial galls has not been worked out. Perhaps some of these galls are secondary in character†. In the grape it is supposed that cracks due to frost afford opportunity for aerial infection of the vine, but the way in which the germs are transferred is still in doubt.

Cross Infection.—While at present the limits of cross infection with different strains of the crown gall organism are not definitely known, yet we do know that crown gall bacteria isolated from several kinds of plants have proved easily cross-inoculable artificially to numerous other species in different plant families. More than one orchardist has also had practical proof of cross infection through contaminated soil. Consequently wise growers will hesitate to risk the chance of transmitting crown gall from one kind of cultivated crop to another by planting susceptible varieties in ground from which plants diseased with crown gall have recently been rooted out.

In the following paragraphs we give some information regarding the character and seriousness of crown gall as it appears on some of the more important cultivated fruits. Since this department has conducted no thorough survey work to determine definitely the extent of damage which it causes in this state, the discussion will be largely general.

The Apple.—Upon seedlings and root-grafted trees in the nursery we find principally the hairy-root condition or galls of a somewhat fleshy nature. See Fig. 21, A and B. On older trees the persistent perennial hard galls are more frequent and in the orchard there appears also upon the trunks and branches an aerial form of the disease. Aerial tumors are rarer than the root or crown form in most localities. They are characterized by the growth of smooth, woody, persistent swellings, which later become warty from the appearance of numerous stubby roots which break out just to the surface. It is not possible for us to state at present exactly how these aerial tumors originate, but the causal organism is similar to that producing other forms of crown gall.

Crown gall and hairy root are very prevalent in the nurseries, and because of laws forbidding the sale of trees affected with this contagious disease, the annual loss to nursery men is very large. Unscrupulous dealers sometimes cut off the galls and sell the trees, but tumors may reappear on such trees.

*For suggestions regarding methods of grafting and nursery practice refer to Dr. G. G. Hedgcock's recommendations in the Bureau of Plant Industry, Bul. 186, U. S. Department of Agriculture, Washington, D. C.

†See paragraph on secondary tumors, page 221

Fig. 21. A. Crown gall on young apple tree. B. Hairy root on young apple tree.

Certain precautions may be adopted, however, in the care of young trees and in the methods of grafting which will reduce greatly the amount of disease in the nursery.*

There have been great differences of opinion regarding the amount of damage resulting in the orchard from planting diseased trees. Some writers have claimed that affected trees never become profitable and that great losses occur among them. Undoubtedly the effects of more serious maladies such as root rot which may affect galled trees, have often been confused with crown gall injury. Careful investigation shows that the effects of the disease in orchards are not as serious as some have supposed. Loss does frequently occur, however, since galled trees are more liable to die the first year or two in the orchard than are unaffected trees. Many trees, on the other hand, seem to recover completely and grow into vigorous and profitable maturity. The writer has seen cases, however, where trees of bearing age were evidently stunted and unprofitable because of the growth of hairy root or crown gall on the roots. The orchardist is urged, therefore, to set the healthiest trees obtainable. If for any reason it is deemed advisable to set out diseased trees, galls and hairy root should not be cut out as the effect of the crown gall is likely to be less injurious than the results of such wounds made when the tree is young. If an old tree affected with crown gall appears healthy and is profitable, it is not recommended to remove the tree or to cut off the galls, since there is little danger of the disease spreading seriously in an orchard and cutting out frequently results in greater damage to the tree than the presence of the tumor. If, however, a tree is rendered unprofitable, it had better be

*See reference at bottom of page 222.

removed, although the grower might try thorough cutting out of the galls and disinfecting and painting over of the wounds, a method which is rarely a complete success as it is ordinarily practiced. In districts where fire blight is prevalent, it has been found that crown galls afford peculiarly favorable points of entrance for the bacteria causing the blight, much damage having frequently resulted in this way. In such districts, therefore, it is recommended to remove a strip of bark an inch wide around the base of the gall and then cut out the entire gall, being sure to remove every portion of it. The exposed surface should then be washed with a solution of corrosive sublimate.

Stone Fruits.—Of the stone fruits the peach is most frequently mentioned as seriously affected by crown gall. It would appear that crown gall has usually a very much more disastrous effect on peach trees than upon apples. The root system is often so affected that the diseased tree cannot establish itself in the orchard, or, succeeding in that, fails to become vigorous and profitable. Never plant a galled tree. Prunes are known to be affected with the disease in Oregon, but most of the cases noted have been on trees grafted on peach roots. Cherries and other stone fruits are also subject to attack but we do not know at present the extent of damage which they suffer in the state. Cases of recovery from crown gall are known to occur among stone fruits as well as among apples.

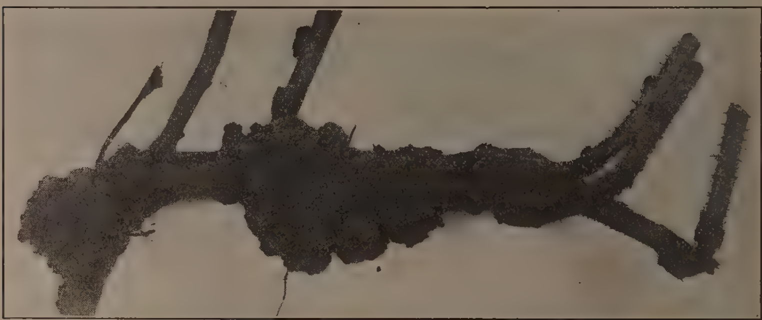

Fig. 22. Crown galls on a loganberry stalk.

Small Fruits.—Raspberries, blackberries, loganberries (Figs. 20C and 22) are often affected with crown gall in Oregon and probably other small fruits are also attacked. The disease not only causes galls on the roots, but on the blackberry, at least. tumors often break forth in long lines from the interior of the canes. A case of what appeared to be hairy root on blackberry was sent to the Department of Plant Pathology during the summer of 1912. Considerable damage seems to result from the effects of the disease on these fruits and it is probable that soil infection and the spreading of the bacteria through the ground to healthy plants is much more serious than among orchard trees. Fruit trees should never be set immediately upon ground from which galled berry bushes have been grubbed out.

Grapes.—Most of the European varieties of grapes are quite susceptible to crown gall, while only a few of the American varieties are considered susceptible. On the grape the disease is found in two forms, as a root gall and as a cane gall. On cuttings and young plants the root form is most commonly found. These root galls are usually formed at a wound and consequently occur frequently at the graft union on grafted vines. On older plants the disease usually also attacks the stem extending from the crown upwards. On the canes the galls are usually confluent and occur in lines running lengthwise of the stem. The effect of the galls is to stunt the vines. The leaves

are frequently smaller and show poor color. The underground galls decay each year and other rot-producing organisms may gain entrance and aid in finally bringing about the death of the vine. The cane galls are reported commonly to start from infection in frost cracks. They may also start in wounds made by pruning or in any other way. The disease is spread in the vineyard in various ways, such as by the water of irrigation, use of diseased cuttings and by insects.

No cure is known for plants that are already diseased and since no experiments with resistant varieties have been conducted in Oregon, no definite recommendations can be made for the grower of European grapes in this state. It is suggested, however, that where the disease is prevalent, it would be worth while to try out experimentally some of the stocks recommended as resistant under more southern conditions in the United States with a view to using such as may prove hardy in Oregon. In New Mexico, where crown gall has been very serious, the Rupestris St. George, Sweetwater, Seedless Sultana, Matosa and some others are found resistant and succeed on their own roots. Benefit has also resulted in the south from grafting the susceptible varieties on such resistant stock as the Rupestris St. George and Lenoir. Among the most susceptible varieties are the Mission, Muscat of Alexandria, Flame Tokay, Malaga and Rose of Peru.

The following precautions should be taken wherever susceptible grapes are grown: Secure cuttings where possible from vineyards free from disease. Where frost is troublesome and infection occurs in the resulting frost cracks, plant deep or protect with some covering. It is best for the grower by propagating his own stock to avoid the possibility of introducing crown gall through grafts or cuttings from infected districts.

Hops.—Crown gall is reported as serious on the hop in some sections of the state. Affected plants should be removed and burned.

Summary.

The Disease.

1. Crown gall in its various forms, which occur on a great variety of plants in many parts of the world, is caused by parasitic bacteria which enter the living cells of the host and stimulate them in some way to multiply excessively, thus producing tumors, the presence of which is usually detrimental to the welfare of the plant.

2. The greatest losses resulting from crown gall occur in the nurseries where the soil becomes contaminated and the trees in their young and tender condition are particularly susceptible to infection through wounds and at the union of stock and cion in root-grafts.

3. In the orchard the effects of the disease are sometimes severe and sometimes slight, depending on many conditions. Apples do not suffer so much damage as do peaches, berries and other fruits. An attack of crown gall is usually detrimental, often serious, and sometimes fatal. A good many affected trees, however, recover or become resistant to the disease. There seems to be little spreading of crown gall in most orchards.

The Control.

4. In order to keep crown gall under control in the nursery, trees or small fruits should never be grown in land previously infected with the disease. Such plants as become infected should not be allowed to remain in the soil until the galls decay, but should be removed and burned. Neither root nor cion used in root-grafting should come from stock having galls or hairy root, and the grafting and wrapping should be carefully done.

5. All nursery stock should be carefully inspected and all trees showing evidence of crown gall and hairy root or previous cutting-off of galls should be discarded. Fruit inspectors should use care in inspecting stock and make sure that every tree condemned is really affected with crown gall or hairy

root. All warty appearances are not necessarily crown gall nor are all fibrous roots necessarily hairy roots. A whole shipment should never be condemned because a few trees are infected, since investigation has shown that there is little or no danger of infection spreading from diseased trees to healthy stock in the same shipment.

6. Growers should never plant a diseased tree. It is better to discard an affected tree than to run the risk that it will never pay interest on the spot of ground it occupies.

7. Trees which are found affected with crown gall in the orchard should be allowed to remain if still profitable, but if unprofitable should be removed. Recovery sometimes results from the complete removal of galls with sterilization of the wounds. Cutting out is recommended, especially in fire blight districts, since galls afford favorable points for blight infection.

8. On account of the great difference in susceptibility of different varieties, a good opportunity is presented in the direction of the selection and breeding of resistant or immune varieties among fruits like the raspberry and grape, and possibly also among some of the tree fruits.

MUSHROOM ROOT ROT OF TREE AND SMALL FRUITS.

By H. P. BARSS.

In various sections of the state, fruit trees are attacked by the disease known as mushroom root rot or crown rot. Starting from isolated trees in an orchard, it often spreads to surrounding trees, forming infested areas, which enlarge from year to year. Examination at the base of affected trees reveals a decayed condition on the underground part of the trunk or on large roots. Under favorable conditions clusters of mushrooms (toadstools) usually appear in the fall at the base of such trees. See Figs. 23 and 25. Old trees and young are equally liable to attack, and once attacked, there is little hope of saving them from ultimate destruction. While this disease has never assumed the character of an epidemic, yet the fact that it is widespread through the fruit-growing districts of the state, constitutes reason enough for considering it sufficiently serious to merit special discussion in this report. It is not our intention to throw any new light upon the malady, but for the benefit of those interested, to give a brief summary of the general facts known about the disease, together with a few tentative suggestions regarding possible means of control.

Distribution.—While no careful survey has been made to determine its exact distribution, the disease is reported more frequently to this department from the northern part of the Willamette Valley and from the Hood River Valley than from other districts in the state, although it is known to exist elsewhere as a common trouble. It also appears destructively in Western Washington and California, and similar root rots are reported from the southern and eastern states. In Europe this trouble has been known for a long time, and the splendid work done in Germany by Hartig is the basis for most of our present knowledge regarding the disease.

Hosts.—From numerous parts of Europe and America it is reported that many forest trees, including various evergreens, the birch, beach, walnut and oak, as well as such fruit trees as the apple, plum, cherry, peach, citrus and olive, besides certain bush fruits and the grape, are attacked by very similar, if not identical, mushroom root rots. Along our Pacific Coast, mushroom root rot is prevalent on many kinds of trees and shrubs. In Western Washington, Lawrence reports its presence among several native trees, both evergreen and deciduous, and mentions that in orchard and field the apple, plum, cherry, gooseberry, currant, blackberry, raspberry and loganberry were found to be badly injured or killed. In California, Horne has reported that it occurs throughout the state, attacking a great variety of hosts. He says that it appears to be capable of attacking almost any plant, in fact, that is

Fig. 23. A young apple tree killed by root rot. The young (button) mushrooms are attached to the trunk where it entered the ground.

Fig. 24. Base of a prune tree which died in the spring. Roots and crown are covered with rhizomorphic strands. Bark is stripped from the trunk, showing white fan-like growth of fungus underneath.

somewhat woody and long-lived. In Oregon no careful investigation has been made to determine to what extent native forest trees may be parasitically attacked, but mushrooms like those usually associated with the orchard disease, are frequently found arising from decayed alder, maple, oak, pine and fir trunks, and further search would probably reveal other kinds affected. In regard to cultivated trees, the attention of the department has been more often called to serious damage resulting from attacks on prunes and apples than upon other kinds of fruits, although in some sections the cherry and peach are badly affected. The walnut also has been found parasitized by the fungus. Further investigation is likely to establish its occurrence also on other trees and probably on small fruits in Oregon, since no thorough survey of the disease has yet been made in the state.

Symptoms.—The symptoms of the disease vary somewhat, depending upon the point at which the tree is attacked, the rapidity or slowness with which the parasitic fungus spreads, and other conditions. It is generally not until the trouble has made considerable progress that the first external evidence of the attack appears in its effect on the health of the tree. The earliest indication is usually a retarded growth, attended by early dropping of the leaves. The foliage generally presents an unnatural appearance. Often this is confined to that side of the tree corresponding with the side of the trunk first attacked. The fruit is usually poor and stunted. A tree may sometimes show such symptoms for two or three years before it finally succumbs, but death frequently occurs during the season in which the symptoms first appear, or during the following year. In rapid attacks, the leaves often become yellow early in the summer. Not infrequently the entire foliage suddenly withers and the whole tree dies in midseason. Again, death may occur during the winter, in which case the tree fails to leaf out in the spring. Sometimes, but not always, clusters of mushrooms of a light brownish color come up in the autumn around the base of the trunk, or push through the soil above diseased roots. In some cases, this occurs before the tree is totally dead.

As soon as a tree shows the first signs of trouble, it should be examined by digging the soil away from the base, and a search should be made for decayed areas on the trunk and roots (Figs. 26 and 27), and for peculiar black, rootlet-like branching strands, mostly about the thickness of the lead in a pencil, clinging to the bark. See Fig. 24. These strands, known as rhizomorphs, are characteristic of the disease, since they are a special form of the fungus which causes the rot. They can be distinguished from the roots of any small plants which may also be present in the soil, by their peculiar irregular method of branching and by the white interior substance which can be rather easily separated from the thin black covering. The dead bark and wood is penetrated by a whitish fungous growth and has a strong mushroom odor. Sometimes rhizomorphs are found on the roots of an entirely healthy tree apparently causing no injury. It is possible that in some instances such strands do not belong to a disease-producing form. This point needs further investigation.

The disastrous effect of the disease results from the girdling of the main roots and the trunk, and from a destruction of the activity of the sap-wood. This brings about root starvation, a checking of the ascent of water through the wood and, as a consequence, the eventual death of the whole tree.

Cause.—The cause of this disease is one of the higher fungi known as *Armillaria mellea* (or varieties) and commonly called, from its usual light, yellowish-brown color, the honey mushroom. Several forms or varieties of this fungus have been found on the Pacific Coast attacking fruit trees or growing from the decaying stumps and roots of oaks and other native forest trees. It is not definitely known whether or not the forms that cause so much damage in our orchards are identical with those common in the neighboring woods and pastures. This question will be taken up in a proposed investigation of root-rotting fungi. The following general description of the typical *Armillaria mellea*, however, will serve sufficiently well to identify the mushroom causing the disease under consideration.

The fruiting bodies or toadstools occur in tufts or clusters, several or many individuals growing together. See Figs. 23, 25 and 28. The entire plant is

Fig. 25. Young English walnut tree killed by mushroom root rot showing cluster of old toadstools at the base.

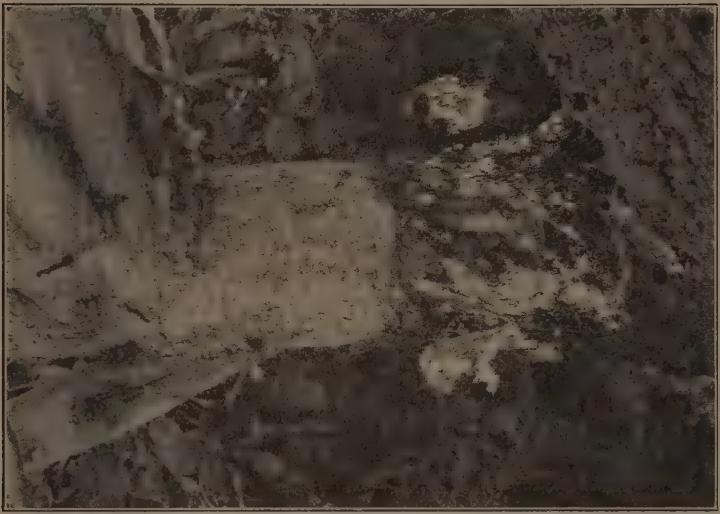

Fig. 26. Trunk of a peach tree which showed first external signs of disease during summer. Photograph taken in the fall. Tree girdled below ground and dead bark cut off, showing white fungous growth.

more or less honey-colored or light brown. There is usually a prominent, irregular ring (annulus) on the stem near the cap. The cap is usually slightly elevated in the center and the margin slightly inrolled at first, but later the cap may be quite flat or concave with the margin expanded or upturned. The color of the cap is quite variable, sometimes nearly white, sometimes yellowish brown, sometimes dull reddish brown. Ordinarily the color is darker on the center. The surface of the cap is usually dry and adorned with little dark, pointed, erect scales more abundant over the center and lighter and more cottony toward the edge. In some forms the cap is entirely smooth. The caps vary greatly in size even in the same clump. They average perhaps three inches to four inches in diameter when expanded, although specimens measuring a foot across have been found in Oregon. Attached to the under surface of the cap are the delicate gills, white or whitish at first, but becoming with age more or less dingy or flesh colored. They are attached to the stem and usually run down it a short distance. The stems vary greatly in length, from four or five inches to twice that or more. They are usually whitish above the ring and brownish below it; sometimes smooth, but often somewhat cottony, with loose scales or strands. In the young condition (button stage) the edge of the cap is connected with the stem by a membrane known as the veil. As the cap expands, this tears away, and is left attached to the stem in the form of a ring or annulus. The veil may be quite thick or very delicate. In some cases it may be absent. The fungus is reproduced by microscopic rounded or elliptical spores which fall in thousands from the gills and are borne about in the air. They are often deposited as a white dust on the ground or on the caps of other mushrooms lower in the cluster.

The mushrooms or fruiting bodies of the fungus may or may not be developed in connection with the disease, depending on the extent to which the decay has progressed, or upon weather conditions and other factors. In Oregon they are most liable to be found in October or November, although they occasionally appear in the spring.

It is very possible that other kinds of mushrooms may cause diseases similar to the one here described. There is some evidence, moreover, that not all fungous root rots are attributable to fungi of the mushroom group, but it seems probable that *Armillaria mellea* or some of its varieties are responsible for the greater portion of the root diseases of woody plants in Oregon.

Life History and Method of Spread.—We have very little exact information regarding the way in which this fungus becomes established or how it enters the infected tree. It is thought by most authorities that after the spore germinates, the delicate fungus plant develops as a saprophyte, feeding upon decaying vegetable matter in the soil. After growing for a time in this manner it may form black rhizomorphic strands, which push their way through the soil, and upon coming in contact with the root of the susceptible plant, may possibly bore their way into the healthy bark. It is believed by many, however, that the fungus gains its entrance, more often, if not exclusively at points where the root or the crown of the tree has been injured by cultivation, by the attacks of borers, or by the presence of a crown gall, etc. When once it has entered the tree, it sends out delicate filaments both into the bark, where, given the right conditions, it spreads rapidly, and also, by way of the medullary rays (silver grain), into the wood, where it spreads more slowly. It causes death and decay in the parts attacked, and with a whitish, felty growth, fills up the spaces caused by shrinkage of the tissues. See Fig. 26. The bark frequently becomes separated from the wood, and in the space thus formed the fungus spreads out in a fan-like manner. In most cases where the disease has made any considerable progress, this conspicuous feature is noticed upon tearing off the dead bark. See Fig. 24. Sometimes the white fungous layer formed under the bark or in cracks of the wood becomes quite thick. While the rot is thus spreading along a root or the base of the trunk, the fungus frequently breaks out from the bark, and, in the form of branching rhizomorphs, creeps along the surface of the root or trunk, working its way out into the soil. It is probable that these strands may enter the tree again at new places,

thus spreading the attack, or coming in contact with the outlying roots of other trees close at hand, may enter them, and thus cause further extension of a diseased area in the orchard.

The disease spreads fast from the point of attack up and down the root or trunk, apparently working most rapidly in the cambium region. Where a root is attacked, little effect on the tree is at first noticeable, perhaps for several seasons, until in the course of time the decay reaches the trunk, whereupon the activity of the fungus may quickly cause the girdling and death of the tree. Where the first point of attack is at the crown, or near it, the progress of the disease is more rapid than where a root is the initial point of infection. The decay rarely extends more than a foot or two above the ground and is not usually detected on the trunk at first unless the bark is stripped off. After a tree is dead, the growth of the fungus is checked by the drying out of the parts above ground, but it may continue to live in the underground parts, if there is sufficient moisture present, until the roots and stump are entirely decayed. From these rotting roots rhizomorphs run out into the soil and form a means of spreading the disease to the roots of unaffected trees.

Fig. 27. Trunk of apple tree which died in midsummer. Dead bark removed to show layers of white fungus under bark.

When the decay has progressed sufficiently and the fungus is thereby richly supplied with reserve nutriment, the fruiting bodies or mushrooms may be formed. In their young condition these are edible. Abundant moisture is necessary for their development, consequently they are not met with, as a rule, till the fall rains have begun. The clusters of mushrooms usually appear at the point where the trunk enters the earth and may encircle its base. Often they rise through the soil from a diseased root or they may be attached to rhizomorphic strands connected with crown or roots. Observation will show how the small button-like beginnings of the mushrooms burst through the ground, grow rapidly to full size, expand, shed their white spores and then fall in decay. While millions of spores are produced from every cluster of mushrooms, yet very few of them ever find proper conditions for their development. It is doubtful whether they form a source of much danger to well cultivated orchards, but in any case, collecting them in the button stage and burning them before the spores are shed, will prevent any possible spread of the disease by spore dissemination. The greatest danger seems to come from the rhizomorphs rather than from the spores.

A form of Armillaria commonly causes the rotting away of old stumps and roots of oak and other trees that have been left in the ground after clearing. Every fall, in orchards and fields, there appear groups of these mushrooms which may be traced to buried, decaying wood which is usually covered with rhizomorphs. Many people believe that fruit trees planted over or near such old roots or stumps may be attacked by the fungus that is causing their disintegration. Further investigation will be necessary, however, to prove conclusively whether this is true or not in Oregon.

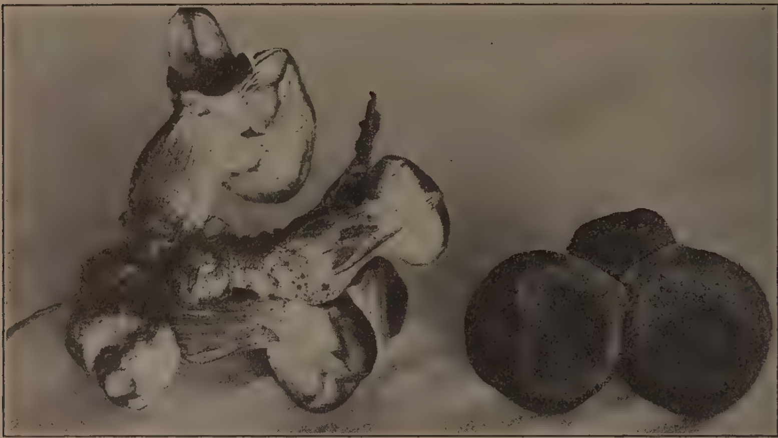

Fig. 28. Mushrooms of *Armillaria mellea* in young condition.

Control Measures.—The suggestions presented in the following paragraphs regarding possible modes of treatment for this disease are in no way to be considered as definite recommendations. The reason for this appears when it is said that nowhere, to the writer's knowledge, have thorough or long-continued investigations of possible orchard control methods been carried out to a successful conclusion. Furthermore, information as to the way in which the trouble may enter an orchard and the exact manner of its spread, is incomplete and unsatisfactory. Very little, moreover, in the way of scientific observation and experimentation upon the disease or upon means of combating it, has ever been carried on in this state. Consequently, this department is not warranted in stating that any of the methods described here are sure to give satisfactory results. It is to be hoped, however, that intelligent growers will try out various methods of treatment experimentally. The Department of Plant Pathology would be glad to receive at any time reports as to the success of such treatments, and offers to co-operate with any who desire to avail themselves of the opportunity.

The prevalent, but not yet convincingly substantiated, idea that buried roots of forest trees in newly cleared land are a dangerous source of infection for young orchard trees, has led to the suggestion that all roots and stumps be carefully removed from the earth in clearing, and that before planting trees, the soil be devoted to other than orchard crops for several years until the root-rotting fungus has had a chance to die out.

Evidence that much of the infection takes place where trees are injured by cultivation leads to the suggestion that cultivation close to the tree be done with greatest care to avoid injury. At the same time thorough cultivation has been advised in order to establish good aeration of the soil. Since this condition is supposed by some to be unfavorable to the progress of the disease while it undoubtedly promotes the vigor of the tree.

When trees are once attacked by the fungus, death, almost without exception, is only a question of time. It seems useless, therefore, to retain in the orchard trees which will be worthless to the owner and which may become a source of infection for other trees. It has consequently been considered best to grub up at once any tree discovered to be diseased and to remove it from the orchard, taking out at the same time as much of the root system as possible. It has also been advised not to plant another tree in its place for at least three years.

If it should seem desirable to retain temporarily a tree known to be diseased, it would perhaps be safest to dig a trench about two feet deep around the tree near the tips of the roots in order to prevent the rhizomorphs, which rarely occur deeper than this, from spreading to other trees. Throw the dirt inside the ditch. Where conditions are such that the disease appears to be spreading rapidly from tree to tree, the heroic method of uprooting healthy trees in advance of the zone of infection has been suggested; but as far as we know, the disease rarely assumes such a condition in Oregon orchards as to warrant so drastic a method of treatment.

On account of the possibility of infection from spores produced by the mushrooms, all fruiting bodies appearing at the base of diseased or dead trees, or in other places in the orchards and fields, should be collected while still in the button stage and destroyed by burning. Knocking them over does not prevent spore formation.

The effect upon the disease of various chemical substances worked into the soil around a tree has never been thoroughly tested out. This line of investigation may prove to be worth while, and growers are urged to make experiments upon trees known to be affected. A record of the exact treatment should be made and notes kept regarding the effect in each case. This department would appreciate all the accurate information which any orchardist can give along these lines.

Those who possess sufficient patience and skill, and are willing to devote the necessary time, may be able by the following method to save individual trees that are not too far gone when the disease is discovered. This method has been used in one Oregon apple orchard with considerable success. Whether it can be applied as well to other kinds of fruit trees remains to be seen. At the first sign of unhealthy foliage the tree is examined for root rot. Where this is found, the earth is removed from the base of the tree and the main roots are exposed for a foot or more. The soil is also removed from beneath the roots. The air and sunshine have access in this way to the crown and root bases. The dead portions of the bark are carefully and completely removed from trunk and roots. If a root is girdled, it is taken out entirely. After all the diseased parts of the tree are cut out, the exposed surfaces are washed with some disinfectant such as Bordeaux mixture or corrosive sublimate. When they are dry, walnut grafting wax is applied. Then, in order to restore as quickly as possible the area of the trunk destroyed by the fungus, bridge-grafting is resorted to. A number of cions are inserted into the healthy tissue of the trunk just above the dead part, and their lower ends are connected with healthy roots. This is a delicate operation and the trees have to be braced to prevent the cions from pulling out. In an orchard recently visited by the writer, a few young bearing apple trees which were treated in this way two years ago are now apparently free from any trace of disease and as thrifty as any of the surrounding ones. The crown and large roots of these trees had been left exposed for two seasons with no apparent ill effect, the earth being thrown back over them, however, each winter. A trial of these methods is recommended. It may be that simple root exposure would help to check the disease or that thorough cutting out and sterilization would stop its progress, but so little experimentation has been done along these lines that definite assurances of success cannot be made.

DISEASES OF POMACEOUS FRUITS.

By H. S. JACKSON.

APPLE DISEASES.

Anthracnose.

Next to apple scab, this is the most serious disease of the apple which occurs in the state. It has been under investigation by the Department of

Plant Pathology for some time and a preliminary report is given on pages 178 to 197 of this report.

Crown Gall and Hairy Root.

One of the most serious troubles of the apple in the nursery is crown gall and hairy root. This disease causes thousands of dollars loss annually to the nurserymen of the state. It also occurs, though more rarely, as an orchard trouble. See special article on pages 218 to 226.

Fire Blight.

The disease known as the fire blight affects the apple as well as the pear. See under pear diseases, page 241, for a brief discussion of this trouble.

Fruit Pit.

This disease, otherwise locally spoken of as the "brown rot," "bitter rot," "bitter pit," "Baldwin fruit spot," etc., is in some respects one of the most serious troubles of the apple in Oregon. It is present in more or less

Fig. 29. Baldwin apple showing typical appearance of fruit pit.

severity in all sections of the state where apples are grown. A common disease, also, in most other apple sections of the United States, it is serious in Germany and other sections of Europe as well, where it is generally referred to as "Stippin." It is also common in Canada, Mexico, Australia, New Zealand and South Africa. The disease is too common to need a detailed description. It seems to be very variable in appearance. The most common condition is the occurrence of sunken areas one-eighth to one-half inch in diameter, which have somewhat the appearance of bruises on the surface of the apple.

See Fig. 29. In the early stages the skin is perfectly normal in color, though often retaining the green tint longer than the surrounding tissue. In red apples the spots may be deeper in color for a time than the surrounding tissue. Later they gradually turn brown. The skin is usually unbroken in both early and late stages.

In cutting an affected apple one finds a browning of the tissue just underneath the sunken areas on the surface and similar discolorations are also frequently found scattered through the substance of the fruit. A close examination shows these discolorations are not entirely separated but are associated with the vascular system of the fruit, and connected with each other by very fine brown strands of diseased tissue. These internal spots are usually more abundant near the surface of the apple and in most varieties are found more numerous toward the blossom end. A larger amount of starch is usually found in the diseased cells than in the surrounding tissue.

Cause.—Unlike most other diseases discussed in this report, the fruit pit is presumably not caused by any organism; at least, no fungi or bacteria have been found associated with these spots. It evidently belongs to a class of so-called physiological diseases. Various explanations have been offered by investigators as to the reasons for the formation of the spots of diseased tissue. Wortman, a German investigator, was the first to study the disease thoroughly. He concludes that the death of the cells is due to the acidity of the cell sap following excessive transpiration, or, in other words, that the trouble is accounted for by the theory that there is a lack of balance between transpiration (the giving off of water by the living cells of the fruit) and conduction (the passage of water and food substances to the cells of the fruit). He gives morphological and physiological reasons to account for the greater prevalence of the disease in particular varieties. Maynard, in Massachusetts, believes that the disease is due to premature, imperfect ripening. Light soils, especially those exposed to the south, and rich in nitrogen, are claimed to favor the spotting. Quinn, in Australia, believes that the factors most influencing the presence of the disease are abundant moisture and high temperature. He also suggests that there may be some influence exerted by the stock upon the scion, and states that in Australia, where the disease is very prevalent, most apples are grafted on Northern Spy stock, which is commonly affected with the disease. He finds, however, that native apples grown on their own stock, are less susceptible. Sorauer, in Germany, claims that the disease is more abundant where dry weather occurs before the fruit is entirely formed. Gussow, writing in England, agrees with this and considers that the spotting is brought about by a lack of sufficient water to supply the necessary sap for the development of the fruit. McAlpine, in Australia, offers evidence to show that complete fertilizers aggravate the disease. I. B. Pole Evans, who has made considerable study of this disease in the Transvaal, concludes that the spotting—

"...results from the bursting and consequent breaking-down of certain cells of the flesh due to too great internal pressure. This great pressure is set up by the external conditions to which the trees are exposed. These trees are not of themselves plastic enough to adapt themselves to their environment, and thereby regulate their physiological functions, with the result that abnormal forces are brought into play with which the plant is unable to cope in the ordinary course of events. In consequence thereof abnormal physiology leads to disease conditions. The main factors that are responsible for the spotting are believed to be excessive transpiration during the day, followed by its sudden checking and complete abeyance during the night, when root action is still vigorous owing to the warmness of the soil. Under these circumstances water accumulation takes place to such an extent in the cells of the fruit that an actual bursting of the cells may occur."

He further concludes that varieties developed in foreign countries are more susceptible to the trouble than varieties developed under local conditions and believes that the solution of the problem in the Transvaal is the development of new local varieties. He presents evidence to show that the colonial varieties grown at the present time are much more resistant than those that have been introduced.

It is seen from the above that there is great diversity of opinion among investigators regarding the cause of the spotting and the factors influencing this disease. On this account further investigation from a physiological and

morphological standpoint, combined with extensive observations and experiments in the orchard, must be made before the problem is satisfactorily solved.

In Oregon the disease is found on soils so diverse both as regards character and richness, and varies so greatly in abundance and severity between different seasons, that the writer is led to the conclusion, on present evidence, that the most important factors influencing its presence from season to season, are certain varying factors of climate which induce the disease by acting through their effect upon the balance existing between the moisture content of the soil, the rate of absorption by the roots and the amount of evaporation from foliage and fruit.

A trouble of the apple also very common in Oregon usually referred to as core rot is characterized by a premature breaking down of the tissues, starting at the core. This is believed by the writer to be closely related in cause to the fruit pit and the factors influencing its presence are considered similar. It must be recognized that among the different varieties of apples the inherent differences in adaptability to certain types of environment and the natural differences in the texture of the fruit gives rise to great differences in susceptibility to such troubles.

These problems are being investigated at the present time by the Departments of Plant Pathology and Horticulture of the Experiment Station, and it is hoped that some practical results may finally be obtained. At the present time, however, no definite recommendations applying to all conditions can be made. Since climatic factors cannot be controlled the most logical line of attack would be to improve the physical condition of the soil by proper orchard practice and the chemical condition by proper fertilization. It is possible that the condition of drainage in an orchard may have an important bearing on the relative prevalence of this disease in some instances. It is suggested that the orchardist can carry on experiments in his own orchard which may throw some light upon the solution of the problem. Upon application to the Agricultural Experiment Station suggestions regarding methods of experimentation will be furnished.

Growers should be cautioned against mistaking the fruit pit for the "fruit spot," prevalent in the eastern United States and particularly in New England, which has long been confused with the former. This fruit spot is caused by a fungus known as *Cylindrosporium pomi*, and can be prevented by spraying, a method which is useless in controlling the fruit pit. So far as we know, the fruit spot does not occur in Oregon.

Powdery Mildew.

The apple powdery mildew is a common disease in nearly all fruit sections of Oregon, but seems to be more abundant in the southern part of the state.

This disease was formerly considered as most serious on nursery stock, but under certain climatic conditions the disease is not uncommon on full grown trees in the orchard. It usually attacks only the tips of actively growing branches, but may occur in spots on the underside of otherwise unaffected mature leaves.

This disease is caused by a fungus known technically as *Sphaerotheca mali*, the mycelium of which develops mainly as a covering on the surface of the growing twigs and leaves and sends feeding threads only into the external cells. The twigs present a white, mouldy appearance, due to the growth of the threads of the fungus in considerable quantity on the surface. See Fig. 30. Sometimes this is so copious as to resemble felt. Spores are produced in great abundance under favorable conditions and give the affected twigs and leaves a frosty appearance. Such twigs are usually more or less thickened and shortened, and frequently distorted. The leaves present a wilted appearance and are smaller than normal.

When the disease is abundant, the normal functions of the tree are interfered with on account of the reduction in the foliage. Affected trees may fail to form blossom-buds, or the fruit may not be of good size and quality.

Fig. 30. Branches of apple attacked by powdery mildew.

The fungus hibernates as mycelium on the affected twigs. This is the principal method by which it is carried over the winter. Sexual spores may also be formed in protected fruit bodies partly buried in the felted mass of mycelium.

Treatment.—It has been found that this fungus, unlike most powdery mildews, is a difficult one to control. Since the fungus winters on the twigs, it might be expected that a dormant spray applied late in the spring would control the disease; but this has not been found sufficient where the disease is abundant. Investigations carried on in California by Volck indicate that a special spray, the iron sulphide, will hold the disease in check so that it will not cause serious damage, if the spray is applied as soon as the foliage buds

open and is repeated at frequent and regular intervals. No investigation of the use of iron sulphide has been carried out in Oregon. Where lime-sulphur can be safely used as a remedy for apple scab, it should not be necessary to use the iron sulphide. Growers who wish to experiment with this spray under Oregon conditions should apply to the Department of Plant Pathology for the details of preparing the mixture which requires great care.

When the disease is present only in slight amount, pruning out the diseased twigs, removing them from the orchard and burning them, will usually be found sufficient to hold the disease in check.

Scab.

Apple scab is the most serious and most generally distributed fungous disease of the apple known, and in the northwest during favorable seasons, west of the Cascade mountains, is particularly severe. In Oregon it is prevalent throughout the coast region and in the Umpqua, Hood River and Willamette valleys. It does not develop seriously in most sections of the Rogue River Valley. In Eastern Oregon it has appeared in some sections, notably in the Grand Ronde Valley.

Symptoms.—Apple scab attacks both foliage and fruit. On the foliage the spots are at first more or less circular in outline, olive green or brown in color, becoming darker and more irregular in shape as they become mature. The leaves are frequently more or less curled or wrinkled. When the spots are abundant, the leaves fall prematurely and considerable defoliation may thus take place when infestation is abundant. This may result in a failure of the fruit buds to develop normally and so affect the amount of the crop the following year.

On the fruit the fungus produces more or less circular spots of a greenish-black color. The vegetative stage of the fungus causing the disease develops under the cuticle of the apple fruit, finally rupturing it by the elongation of the threads which bear the spores. The ruptured cuticle may frequently be seen clinging as whitish membranous shreds about the edge of recently developed spots. As the spots become older, all trace of the fungus may become obliterated and the only evidence of the former spot is seen in a large or small, rough, russetted spot, as shown in Fig. 31. Frequently the fruit is distorted when mature as the result of early scab infections. Where scab spots are abundant the fruit may become cracked. Scab in any degree of severity on the fruit renders it unsightly and unmarketable as fancy fruit.

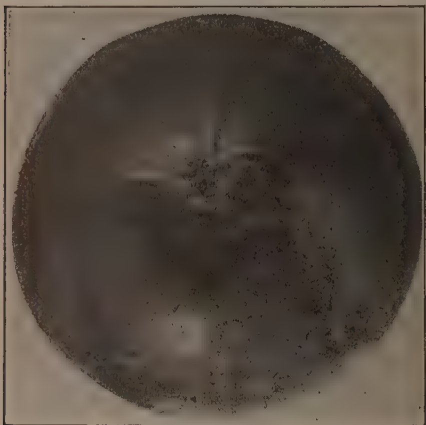

Fig. 31. Apple infested by scab. Old stage. Note russeted spot.

In the spring of 1912 at Corvallis, apple scab was observed to develop abundantly while the trees were in blossom on the sepals, petals and ovaries, as shown in Fig. 32.

Cause.—As noted above, apple scab is caused by a parasitic fungus. The technical name of this fungus is *Venturia pomi*. Two distinct phases are known, the conidial or summer spore stage and the sexual or ascus spore stage. The summer spore stage develops on both foliage and fruit in spring and summer and causes the spots described above. The spores of the fungus are pro-

duced in the spots on leaves or fruit in great abundance, and are disseminated by the wind, spreading the disease to other leaves and fruit. One finds the

Fig. 32. Apple scab on blossoms. Note spots on petals, sepals and ovaries.

scab spots first appearing in the spring on the under side of leaves on the lower branches. Spores produced in these spots are disseminated to other leaves and to the developing fruits. Several generations may thus occur during a single season.

The mycelium of the fungus present on the leaves which fall to the ground in the autumn does not die, but develops in these leaves during the winter as a saprophyte, and in the spring produces spores quite different both in manner of formation and in the shape and size from those borne in the spots on living leaves and fruit. The spores found in the spots on leaves and fruit are one-celled, rarely two-celled, and are borne on the ends of short threads, while the spores developed on the dead leaves in spring are always distinctly two-celled and are borne in little cylindrical sacs called asci. A considerable number of these sacs are borne in a hollow, more or less pear-shaped receptacle buried in the tissues of the leaf. These receptacles containing the asci are known as perithecia, and when mature project as little black elevations from the surface of the leaf. These are barely visible to the naked eye. At maturity an opening appears in the projecting elevations. The asci elongate and protrude through this opening and forcibly eject the spores, which, wafted by currents of air, may be carried to the young leaves of the apple, where they germinate and produce the first scab spots. The sexual spores are disseminated about the time the blossoms open. So far as is known, all primary infection of the leaves and fruit in the spring takes place as a consequence of disseminations of the sexual spores. Subsequent infections result from the dissemination of the conidial or summer spores.

The development of the scab fungus is found to be very much influenced by weather conditions. Moisture on the surface of leaves and fruit is essential to the germination of the spores and the consequent infection of the plant. On this account scab is found to spread most rapidly in the spring, early summer and late fall. The disease spreads little, if any, during the summer in dry seasons. In seasons of frequent summer rains, as in 1912, scab may spread all summer, if the trees are not properly protected by spraying.

Apple scab is not uncommonly found developing in storage. If fruit infested with scab is stored the fungus may continue to develop around the edges of the old spots. New spots due to infection in storage may also occur.

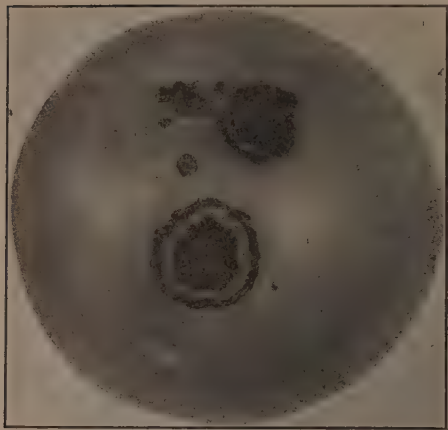

Fig. 33. Apple Scab developing in storage from old spots. Note new infections also.

Fig. 33 shows the fungus spreading from old scab spots and also the presence of new infections on a Newtown apple which had been kept for some time in storage. It is not uncommon to find small black spots of apple scab developed on apples in storage, particularly in the hollow about the stem. This may occur on fruit that was perfect when stored.

Treatment.—As with all fungi of this nature, treatment must be preventive rather than curative. The method of treatment is dependent on the life history of the fungus causing the disease. Since the fungus winters over on the fallen leaves, it would be advisable to destroy all such leaves before blossoming time. The usual recommendation is to plow the orchards early in the spring before the trees blossom, in order to bury the leaves in which the ascogenous spore stage is developed. Theoretically, the best way to destroy the leaves would be to rake and burn them before plowing, but pathologists have hesitated to make this recommendation on the grounds of impracticability.

In any case, the trees should be given at least three sprayings during the spring. The first application should be made as the blossom buds begin to separate in the cluster and show color; the second should be applied just after the petals fall, followed by a third application 10 days or two weeks later. Should the third application be followed by prolonged rains, a fourth may be found profitable.

Formerly Bordeaux mixture was used almost entirely as a preventive of scab, but in certain sections of this country, notably under the climatic conditions prevalent in the northwest, the injury from russeting has been so severe as to make its use prohibitive. On this account lime-sulphur has largely supplanted Bordeaux as a remedy for this disease.

In the Willamette Valley repeated experiments conducted under the direction of Professor A. B. Cordley have shown that lime-sulphur (stock solution 30° Baume) diluted 1 to 30 with water, applied in three sprayings as recommended above, has given excellent results in the control of apple scab. This method is now used by most growers in this section.

In the Hood River Valley experiments with lime-sulphur were also conducted, and with excellent results so far as the fungicidal value of that spray is concerned. In some seasons, however, growers in that section complain that considerable spray injury has resulted from the use of lime-sulphur. This has left many in doubt as to the best method of controlling the disease in the Hood River Valley. Further investigation is needed to furnish a satisfactory solution of the problem. Until such experimentation is carried to successful conclusion, the writer suggests that Bordeaux mixture, 4-4-50, be used for the first spraying, followed by two applications of *self-boiled lime-sulphur*, 10-10-50, at the time recommended above for the second and third sprayings.

Self-boiled lime-sulphur is a special spray originated for use on the peach for the control of brown rot and peach scab in the east. It is not as good a fungicide as the commercial lime-sulphur or Bordeaux mixture, but it has

the advantage of not causing injury to the very tender peach foliage. There is every reason to believe that it would not cause injury in the apple in Hood River and growers in that section are urged to give it a thorough trial. This spray mixture must not be confused with the old *home boiled lime-sulphur.* Directions for the preparation will be found in Circular Bulletin 13 of the Oregon Experiment Station, copies of which will be mailed on application to the Secretary. The arsenate of lead used for the control of the codling moth may be used in combination with this spray. If growers who try this method will report their results to the Department of Plant Pathology, the department will appreciate the courtesy.

The fall applications of Bordeaux mixture recommended for the control of the apple tree anthracnose, will doubtless have a tendency to reduce the spread of the apple scab in the fall and may prove to have a beneficial effect in retarding the development of the ascogenous stage in the leaves which fall to the ground coated with the spray.

PEAR DISEASES.

Fire Blight.

Fire blight is the most serious of all the diseases which attack the pear and apple. It is a contagious disease of bacterial origin, which, under proper conditions, may attack any part of the tree. Besides the pear and apple, the quince, wild crab-apple, hawthorne, mountain ash, serviceberry and some other pomaceous trees are subject to attacks of this disease.

Distribution.—Fire blight is known to occur in Oregon, at the present time, in the northeastern part of the state in Union and Umatilla counties and as far west along the Columbia as the Hood River Valley, and in the southwestern part of the state, including the Rogue River and Umpqua valleys. It is not at present known in the Willamette Valley nor in the coast region. It is known to occur in Klamath, Grant, Baker, Crook and Malheur Counties, and is perhaps quite generally distributed throughout central and eastern Oregon, though the details of the distribution in that part of the state are not known.

Cause.—Fire blight is caused by a minute organism belonging to the bacteria and known technically as *Bacillus amylovorus.* It is a rod-shaped, motile germ which divides very rapidly by simple fission and is found in immense numbers in the diseased tissue. The germs are so minute that they measure only about 1-25000 of an inch in length and are visible only under the highest magnification of the compound microscope.

Life Cycle.—Beginning in the spring the first apparent damage produced by the disease in an infected orchard is the blighting of the blossoms. Infection is brought about by insects, principally bees, which, after visiting a case of hold-over blight and becoming covered with the organisms contained in the sticky exudation that develops under favorable conditions from old cankers in the spring, inoculate the flowers in their search for nectar. The organisms divide and multiply in the nectar and are able to enter the living tissues through the unprotected nectaries. Having entered the tissues, they quickly blight the blossoms, pass down the blossom-stem and into the fruit spur, killing the tissues and cutting off the leaves from water supply, causing them to shrivel and dry, thus producing "fruit spur blight." The latter occurs several weeks after blossom infection. In very serious cases nearly all the fruit spurs may be blighted in this way and the trees may set no fruit. Sometimes the germs die out and do not grow into the twig or branch on which the spur occurs, but quite frequently they may work into the bark of the branch at the base of the fruit spur, when they form a typical canker. Fruit spurs on the larger branches are a common source of body infection, many cases of blight canker originating in this way.

Blight cankers may also originate either through infection taking place at the tip of young, actively growing branches, particularly if these be water sprouts on the larger branches or trunks, or through infection gaining a foot-

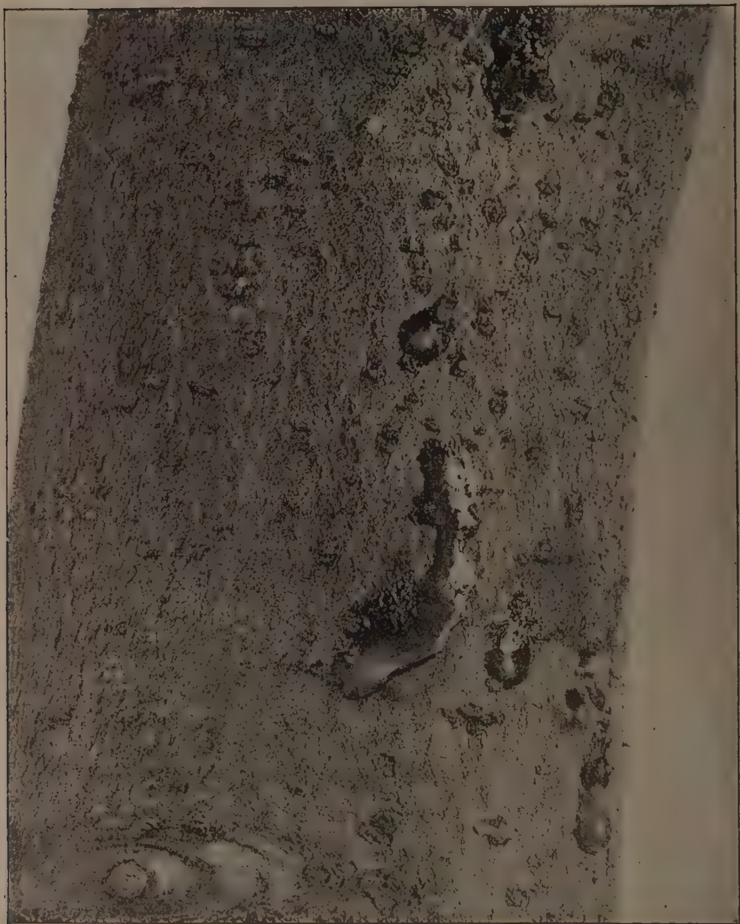

Fig. 34. Active canker of fire blight on apple branch. Note drops of exudation. After Whetzell.

hold in wounds of any kind. Fig. 35 shows a canker originating from infection in a water sprout. Such cankers on the larger limbs and trunk may retain active germs over the dormant season and form the so-called "hold-over" cankers, which doubtless afford the only source of infection for the blossoms in the spring. The disease progresses most rapidly in the fleshy outer layer of the bark and at first produces a watery appearance in the affected area. Later the tissues of the bark are more or less broken down and the cankers, becoming dark in color and slightly sunken, are filled with the gummy substance which exudes from active cankers. This exudate is at first sticky and contains myriads of live germs. See Fig. 34. It is attractive to insects, which visit such cankers in great abundance and become covered with the organisms

Fire blight is also known to attack the fruit, either when half grown or when nearly mature. The germs are doubtless introduced by insects. Under these conditions the disease causes a rapid rot usually with abundant exudation of the germ-laden ooze as shown in Fig. 36.

Fig 35. Blighted twig on pear branch. Note canker on the branch at the base of the twig. After Whetzell.

Fig. 36. Pear fruit rotted by the fire blight germs. Note the milky white exudate. This is filled with myriads of germs.

Modes of Infection.—All parts of the pear and apple tree, except the nectaries and stigmas in the blossoms and the actively growing tips of branches, are covered by a protective layer of tissue, either cuticle or bark, through which the blight organisms cannot enter. The germs, therefore, except in cases of blossom infection and some cases of twig blight, can enter only through wounds which expose the sappy portion of the bark. Wounds may be caused in various ways as by punctures of insects, birds (sap suckers), gnawing of animals, barking or otherwise wounding by careless farm hands in cultivation, pruning or picking. Germs may also enter through growth cracks.

Spread of the Disease.—The fire blight germs are naturally disseminated chiefly by insects at blossoming time. As noted above, active hold-over cankers exude a sticky ooze, attractive to insects, in which the bacteria are present in enormous numbers, and any insects visiting such cankers may become covered with the germs. If, after becoming infected in this way, they visit the blossoms for nectar, they inoculate the flowers, whereupon the germs find an easy access to the inner tissues of the blossom through the nectaries. Actively spreading cankers also exude the germ-laden ooze, and insects may spread the disease to wounds on the branches or trunk. Bark boring beetles may carry the disease in this way. It is probable that a portion of the infection of the twigs resulting in twig blight may be brought about by insect

punctures. Aphids doubtless cause much of this sort of infection. The feet of birds may become infected with blight germs and the disease thus carried long distances. Sap suckers may "tap" an active canker and carry the germs to uninfected trees. Typical cases of body blight have been traced by Waite to this sort of infection. Rain may wash the germs from the ooze of active cankers to wounds, insect punctures, or growth cracks lower down on the branches or trunk of the same tree.

One of the most fruitful sources of infection has been the pruning shears or saw. In pruning, if an active canker is cut into, the tools become infected and serve as inoculating instruments to spread the disease throughout the orchard.

Conditions Favoring the Disease.—The disease is more prevalent in orchards which are rapidly growing and in a succulent condition due to naturally rich soil, abundant cultivation, or application of nitrogenous fertilizers. Heavy winter pruning also has a tendency to stimulate rapid and succulent growth and renders the tree more subject to the attacks of the blight. Irrigation should be reduced to a minimum in infested orchards.

Methods of Control.—The only method of treating diseased trees is to cut out the diseased parts. Spraying is of no value as a control measure. The only method of controlling the disease is by frequent summer cutting, to prevent the spread of the disease and the formation of the hold-over cankers. If hold-over cankers are formed, they must be removed before the trees blossom in spring.

Summer cutting must be practiced constantly. The trees should be frequently inspected and all cases of blight carefully removed. Properly conducted summer cutting prevents much of the spread of the disease and results in the saving of many large branches which might become diseased by the spread of the germs downward in the bark. Trees are frequently killed by the infection starting in a fruit spur or twig, perhaps in the top of the tree, and spreading downward till the trunk is reached. The disease may even spread to the roots. The germs spread very rapidly under favorable conditions and a tree may be girdled in a few days. If such trees are watched and the disease cut out as soon as detected in the fruit spur or branch, they can be saved.

Special effort should be directed toward removing every case of blight canker during the fall, early winter or spring when the cankers have become more or less limited in their growth and are not too actively spreading. *If every hold-over canker could be removed from an orchard district before the sap starts in the spring, the disease would be eradicated.*

Method of Cutting Out Blight.—Where cankers occur on small limbs or are so extensive as nearly to girdle the limbs on which they occur, the whole limb or branch should be removed. In cutting off such a limb it is important that the cut should be made well below the area of infection. For safety, the cut should be made at least a foot below apparent infection, since in actively growing cankers the discoloration of the bark is frequently so slight as to be easily overlooked.

Where cankers occurring on the larger limbs and trunks are not too extensive, the limb or tree may frequently be saved by carefully shaving off the diseased bark of the cankers to the sapwood. Here again one should cut well beyond the point of infection, especially above and below the cankers, since the germs spread most rapidly up and down from the point of infection. Fig. 37 shows a branch treated in this way.

Sanitary Measures.—In cutting out the cankers it is necessary that the tools be kept moist with some good disinfectant. If this is not done when cutting out an active canker, each cut will reinoculate the germs into the bark at the edges of the canker and the labor may thus be useless.

Corrosive sublimate in a solution of one part to 1000 of water has been found to be the most satisfactory disinfectant. It is convenient to carry a sponge or cloth which is kept moist with the disinfectant and used to wipe off the tools after each cut. After the process of cutting out a canker is completed the surface should be carefully disinfected and then painted over with white lead paint.

When cutting out twig blight or when pruning out badly diseased limbs, the same precaution should be taken and the pruning tools sterilized after each cut. All pruned branches should be taken immediately from the orchard and burned. This is especially important if cutting is done in summer.

In infested districts frequent sterilization of all tools used during regular summer or winter pruning should be made a regular practice, since it might happen that a hold-over canker be cut into, the tools become infected, and the disease thus spread throughout an orchard.

Inspection.—Every orchardist in an infected district should examine all pear and apple trees at frequent intervals during the growing season and cut out all diseased portions. The trees should be particularly examined for cases of the collar rot. It is this form of the disease that causes many trees to be killed outright.

Fig. 37. Large canker of blight on apple. Bark removed to show extent of injury

In infected regions it has been found practical by the most successful owners of commercial orchards to keep one or more men in the orchard during the summer and fall, whose sole duty it is to locate and cut out all cases of blight cankers as soon as they appear. This work of inspection and eradication can very profitably be carried on during the summer and special attention should be given to inspection in the fall, early winter and early spring. If an orchard is gone over carefully by trained inspectors in fall and spring, and all cases of this so-called "hold-over" blight are cut out, there will be no source of infection in the spring and consequently no blossom blight.

On account of the manner of dissemination of the fire blight, this disease is peculiarly a community problem. While each individual grower should take an active interest in the disease and inform himself regarding it, the experience, unfortunately, has been that as a general rule the growers are not uniformly to be depended upon. This condition necessitates a system of rigid inspection by authorized inspectors who should be thoroughly trained, and competent for the work. These inspectors must have the undivided support of all growers.

Practicability of Controlling Fire Blight.—Fire blight has proved so widespread and destructive and has ruined so many pear and apple orchards in various sections of the country, that many persons have the erroneous idea that it can not profitably be controlled. In recent years it has been proved conclusively that where all the pear and apple growers in an infested district work together, and where an efficient inspection service is in operation, the control of fire blight is practicable.

General Considerations.—The importance of knowing the disease thoroughly before any attempt is made to practice the method of treatment recommended, cannot be too strongly emphasized. Fire blight must be cut out properly. Serious losses have frequently occurred, due to unintelligent and careless cutting. Frequently more damage is wrought by attempts to cut out the disease by persons who do not understand it, than would be caused by allowing it to run its course. If fire blight appears in an orchard in any form and the grower has had no experience with it, then he should send for

someone at once who knows the disease and who will do the work or will instruct the grower how to practice the proper method of eradication. It is always better to leave the work where possible to some reliable person who has had experience and has become expert in detecting blight in all its forms and in the method of eradication. In any case, it is important that all the work of eliminating blight from an orchard be under the supervision of some one who knows the disease thoroughly.

In cutting blight from an orchard it is best to consider as blight, all doubtful cases and to cut them out.

It is especially important that all growers realize their responsibility as individuals in regard to fire blight. A grower who leaves blight in his orchard knowingly, or on account of careless inspection, may be responsible for a serious outbreak the next season, not only in his own orchard but in any or all orchards in the immediate vicinity.

Every grower should understand that for blight to appear in his orchard is no discredit to him or reflection on his care or ability as an orchardist, but to allow it to remain without proper treatment and a thorough attempt at eradication, would be a discredit. Blight is more liable to appear in serious form in an orchard that is in a high state of cultivation than in one which is improperly cared for or neglected.

Fire blight is spreading rapidly and if adequate measures are not soon taken to arrest its spread, we may expect the disease to be present in a very short time in all parts of the state.

It is obviously of vital importance to all horticulturists living in blight-infested districts to see that every effort is made to control this disease. It is of almost equal interest to horticulturists in sections where blight is not now present. If blight is properly controlled in those sections where it is now present and every effort is made to prevent its spread, it will be a much longer time before it will appear in new districts. Every year that this blight is delayed from appearing in orchards of the Willamette Valley, for example, means thousands of dollars to the growers of that district.

If it is found that present methods fail to control blight in sections bordering on uninfested districts, then the horticultural interests of both districts should unite in demanding state aid to control and prevent the spread of this dreaded disease.

Scab.

The pear scab is undoubtedly the most serious fungous disease of the pear known to occur in Oregon. This disease is abundant throughout the western part of the state, especially in the Willamette and Umpqua valleys and in the coast regions. It does not occur as a serious disease in the Rogue River Valley. It is very similar in nature to the scab of the apple, and the general appearance is the same. Fig. 38 shows well the appearance of the disease upon the fruit. Unlike the apple scab, the pear scab causes a disease of the twigs, producing olive-brown cushions of tissue beneath the epidermis, which finally break through, giving a rough appearance to the twigs. Frequently cankers of some size start upon rapidly growing twigs, which not uncommonly may be girdled. There is considerable evidence to show that on the pear the disease may live over the winter on the twigs.

Cause.—Pear scab is caused by a fungus which is very similar in morphology and life history to the apple scab, but it is due to a different fungus known technically as *Venturia pyrina*. The summer spore stage of the disease is formed abundantly in the spots on the foliage, fruit and twigs. These are disseminated by the wind and serve to spread the disease. Like the apple scab this fungus produces a sexual spore stage on the dead leaves in the spring.

Treatment.—Since the fungus may live over winter on the decaying leaves, it is advisable to plow early in spring, sometime before the trees blossom, in order to bury as many leaves as possible. Smith, in California, has studied the disease, and recommends a dormant spray late in the winter, and further advises spraying twice with Bordeaux mixture while the buds are unfolding.

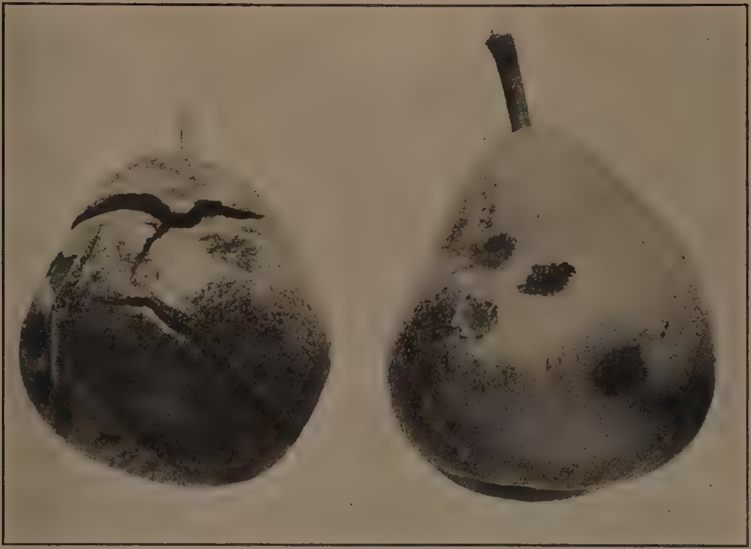

Fig. 38. Scab on fruit of pear. Badly affected fruit may become cracked as shown in left hand specimen.

In the Willamette Valley pear scab has been successfully controlled by the same methods recommended for apple scab on page 240.

Where the disease occurs abundantly on the twigs, as it does particularly in the coast regions, it might be advisable to follow the California method, after previously pruning out as many of the affected twigs as possible. Where orchards have been neglected, and on this account an abundance of twig infection is present, it is probable that several years of careful spraying will be necessary to bring the disease under control. Under such conditions, severe cutting back before spraying, where consistent with good horticultural practice, will aid greatly in subduing the disease.

QUINCE DISEASES.

Anthracnose.

Mr. C. C. Cate, formerly assistant in plant pathology at this institution, records (see page 189) the presence of apple tree anthracnose as a disease of the quince. The writer has also observed this disease upon several occasions in the vicinity of Corvallis, first in the fall of 1909. We are informed by W. H. Lawrence that he found the disease quite common in the Hood River Valley in the fall of 1911. It is apparently not infrequently found on the fruit, particularly in seasons of early fall rains. It also causes small cankers on the branches and twigs. No experiments looking toward the control of this disease on the quince have been carried out, but it is probable that fall spraying with Bordeaux mixture, as for the apple, would control the trouble. Apple trees in the vicinity of quinces should be protected by fall spraying in order to prevent the disease from spreading to the quinces.

Fire Blight.

The disease known as fire blight, discussed on page 241, is also known to attack the quince. In districts where fire blight is prevalent, quinces should be inspected as carefully as apples and pears, and the treatment recommended for the control of the disease on those crops should be followed out.

Leaf Blight.

In rainy seasons the leaf blight of the quince, due to *Entomosporium maculatum*, which causes spots on the foliage and fruit is occasionally found in Oregon, though it is seldom serious. This disease may be controlled by spraying with Bordeaux mixture, first as soon as the petals fall, followed by two applications at intervals of two weeks.

DISEASES OF DRUPACEOUS FRUITS.

By H. S. JACKSON

BROWN ROT OF STONE FRUITS.

The brown rot is one of the most serious and widespread diseases which is known to attack the stone fruits. In most of the peach growing districts of the East and Middle West this is the most serious disease, and in seasons of frequent summer rain may cause enormous losses. In Oregon, on account of less frequency of summer rains, the disease seldom appears in epidemic form, but is not uncommon on the prune, peach and cherry, and occasionally on the apricot.

Fig. 3. Peaches affected with brown rot fungus. Note how the fungus has spread from the badly diseased fruit to the others in the cluster.

Symptoms.—The fruit is most commonly affected. The disease appears first as small, dark brown decayed spots, which gradually increase in size till the whole fruit is affected. The rot does not at first cause any shriveling of the tissues, nor do the spots become sunken. On the well developed spots one finds the spore-bearing structures of the fungus that causes the disease, abundantly produced. These consist of cushions of threads bearing great numbers of spores in chains. They appear on the surface of fruits as little velvety cushions of mold not more than one-eighth or three-sixteenths of an inch in diameter. See Fig. 39. The decayed fruits frequently have a tendency to remain on the trees and slowly dry up, and may cling to the trees during the winter in a shriveled and dried up condition known commonly as "mummies." The fungus lives over the winter in such mummies, and spores, which are produced from them in the spring, start new infections.

A blossom blight may result from infection of the blossoms early in the spring. A twig blight may also be produced, but this probably only occurs when the blossoms or fruit have been infected and the fungus has gained entrance to the twig through them. The fungus is probably not able to enter the twigs directly. Peaches and apricots have been found to be more susceptible to the twig form of the disease than the other stone fruits.

As stated above, the fungus winters over in the "mummies" left hanging on the trees or lying on the ground. It is probable, also, that the disease may be carried over the winter by spores adhering to bud scales, twigs, etc.

Cause.—The brown rot on plums, peaches and apricots is caused by a fungus known as *Sclerotinia fructigena*. This fungus exists in two spore forms. The summer spore form has already been described. The winter or sexual spore stage develops in the early spring from mummies that have fallen to the ground. This stage does not ordinarily develop on the mummies until after they have lain on the ground for 18 months.

This stage of the fungus is developed from resting masses of mycelium called sclerotia, which develop in the tissues of mummified fruits. A definite fruit body is produced known as an apothecium and commonly spoken of as a "cup fungus." This consists of a slender stalk bearing at the summit a cup-shaped structure, one-quarter to one-half inch in diameter. These are found at the surface of the ground, surrounding buried or half-buried mummies. Several may be formed from the same mummy. The inner surface of the expanded bell-shaped portion is lined by great numbers of cylindrical sacks called asci, each of which contains eight spores. These asci form a smooth layer. The details of structure are visible only on microscopic examination. The spores are ejected forcibly from the asci, and, wafted by currants of air, reach the trees. It is probable that much of the blossom blight is caused by direct infection from these spores.

Control.—From what has been said, it is evident that the destruction of all mummified fruit in fall and winter would aid in controlling the disease. It is a bad practice to allow diseased fruits to remain in the orchard, since, as shown above, the fungus is capable of living over winter in such mummies and starting the disease in the spring. Plowing in the spring before the buds open is to be recommended where possible, and when consistent with good horticultural practice. This method would probably not entirely prevent the formation of the winter spore stage and therefore, where practical, the decayed fruit should be gathered and destroyed in the fall.

Peaches should be thinned so that no two fruits touch each other, as it is found that moisture may be retained at the point where the fruits touch and thus favor infection.

Where the disease is serious the trees should be protected by a fungicide. Since this disease is not serious in all sections of Oregon, spraying, as a general orchard practice, may not be necessary for all growers. Previous experience must be taken into consideration in deciding whether sufficient loss is likely to occur to warrant spraying.

It has been found in most peach growing sections to be unsafe to use Bordeaux mixture or commercial lime-sulphur on peach foliage except in very

weak strength, so that a special spray known as self-boiled lime-sulphur* is recommended for use on peach foliage.

The following method of preventing brown rot on the peach in the East and Middle West has been recommended by Scott: 1. Three or four weeks after the petals fall spray with 8-8-50 self-boiled lime-sulphur. 2. Three weeks later repeat, using same mixture. 3. Spray again about one month before the fruit is expected to ripen with the same mixture. It is probable that this method would control the disease in Oregon, though no local experimental work has been conducted.

On the prune, Bordeaux mixture, 4-4-50, or commercial lime-sulphur, 1-30, would doubtless be safe to use. The applications should be made as recommended for peach.

Scott has shown that the self-boiled lime-sulphur, 10-10-50, the commercial lime-sulphur, 1-40, and Bordeaux mixture, 2-4-50, may be used safely on the cherry in the East. The writer would suggest that cherry growers who find it advisable to spray for this disease, try any one of these mixtures.

CHERRY DISEASES.

Brown Rot.

The rot caused by *Sclerotinia fructigena* on many stone fruits, is sometimes serious also on cherries. Moist weather conditions near the ripening time are favorable for the rapid development and spread of the disease. The fruit is more susceptible as it becomes mature. The disease makes its appearance on the cherry as a small brown spot, which gradually enlarges until the whole fruit is affected.

A general discussion of this disease together with recommendations for its control, will be found on the preceding pages.

Gummosis.

A preliminary report of the investigations of the Department of Plant Pathology, which have been conducted by F. L. Griffin, and later by H. P. Barss, is given on page 198 of this report.

Leaf Curl or Witches' Broom.

This disease is quite common in Oregon, but is not yet very serious. It is caused by a fungus, *Exoascus cerasi* which attacks the branches. The affected branch is not killed, but the presence of the fungus stimulates it to an unnatural and prolific formation of twigs, resulting in the peculiar "witches' broom" effect. These witches' brooms may be large, as in Fig. 40, or small, and are especially conspicuous at blossoming time, since they produce few flowers or none at all, while the leaves appear sooner than those on the normal parts of the tree. These leaves, which are penetrated by the fungus, are reddish in color and somewhat wrinkled or wavy. Not long after they become fully expanded the spores of the fungus are produced all over the surface and the affected leaves fall prematurely.

Control.—Since the witches' broom produces no fruit, and is a drain on the rest of the tree, and a source of new infections, we recommend that the affected branches be cut off, a few inches below the diseased portion, and destroyed.

Leaf Spot or Shot-hole.

There are several leaf spot and shot-hole diseases which are more or less common on various stone fruits; but the greater part of this sort of injury on the cherry and plum is due to the fungus called *Cylindrosporium padi*. The trouble caused by this organism in Oregon is not usually severe enough to alarm growers, but there is reason to think that the extent of damage is underestimated. While the amount of leaf area which is destroyed by the fungus

*Those interested in the preparation of this mixture are referred to Circular Bulletin 13, Oregon Experiment Station, for details.

Fig. 40. Cherry tree showing large "witches broom" caused by infection of *Exoascus cerasi*. Note that no blossoms are produced on the "witches broom."

is generally not very extensive, the presence of the shot-hole spots on the leaves often results in partial defoliation, and in bad cases, even in total defoliation of the tree. This is naturally a severe check on its development. At the points where the infections take place, a small brownish spot appears. This enlarges, and may be surrounded by a reddish border. After a time, the dried center of the spot becomes detached from the margin and falls out, leaving the shot-hole effect. On some varieties of cherries the center does not drop out, however, as it does in our common sweet varieties. The disease is spread by means of spores produced in the affected spots and the fungus probably survives the winter in the fallen leaves from which, in the spring, spores are carried to the new foliage by the wind.

Control.—The disease can be largely controlled by spraying. According to W. M. Scott, of the U. S. Department of Agriculture, who experimented in Illinois, self-boiled lime-sulphur 10-10-50, commercial lime-sulphur 1-40 and a weak Bordeaux mixture 2-4-50 are equally effective. Recent experiments by Butler in Wisconsin indicate, however, that Bordeaux is more effective than commercial lime-sulphur. It is recommended that the spray be applied

Fig. 41. Peach leaves affected with the fungus causing peach leaf curl. Note the wrinkled and distorted tissues.

three times: First, half way between blossoming time and the ripening of the fruit; second, just after picking; third, about one month after the second. No experiments have been carried on in Oregon, however, to test the comparative efficiency of these sprays.

Mushroom Root Rot.

The cherry is to some extent subject to this disease in Oregon. A full discussion of the nature of the trouble and its treatment will be found on page 226.

PEACH DISEASES.

Leaf Curl.

The most common and destructive disease of the peach in the humid sections of the Northwest, and probably wherever the peach is grown in this region, is without doubt the peach leaf curl or "curl leaf," as it is most commonly known among growers.

Symptoms.—The disease may be recognized by the characteristic effect upon the foliage and twigs. The leaves are peculiarly and characteristically curled as shown in Fig. 41. This curling results from a stimulation induced by a parasitic fungus, which grows among the cells of the leaf. The infected leaves become considerably increased in thickness and breadth. The cells of the tissues develop thickened walls and increase in size and number. The tissues of the midrib do not increase to any extent and the abnormal growth in the tissues on either side, as described above, results in a puckering or curling. Since the greatest growth is in the tissues toward the upper side, there is a tendency for the upper surface of the curled leaf to be convex. Affected twigs are increased in thickness and very much shortened. (Fig. 42.) The green coloring matter normally present in healthy twigs is bleached out so that diseased twigs appear whitish.

Cause.—The parasitic fungus causing the trouble is known as *Exoascus deformans*. The vegetative condition of the fungus (the mycelium) is present among the cells of all diseased tissues and absorbs the juices needed for the proper growth of the tree, thus stimulating the tissues to produce the abnormal structures described above that are not able to properly perform the functions of normal tissues. Reproductive bodies or spores are produced in little sacs which form a layer on the surface of affected leaves. These form under the cuticle, finally pushing it off and imparting to the surface a frosted appearance. In each sac are borne at first eight spores. These become greatly increased in number by budding within the sac. The spores thus formed escape by the rupture of the sac. These spores, which are presumably carried over the winter on the surface of twigs and bud scales, produce infection as soon as the leaf buds open in spring.

Affected foliage usually drops, and, where abundant, may cause more or less complete defoliation of the tree. Such trees set little or no fruit. Defoliated trees usually leaf out again, so that in midsummer little sign of the disease may be found. The effect of such defoliation, however, is to stunt the tree. Trees allowed to become infected year after year are usually unprofitable.

Besides the method mentioned above, the fungus may be carried over from one season to the next by the mycelium living over the winter in the twigs. The fungus probably gains entrance to the twigs by the growth of the mycelium down the leaf stalks of affected leaves into the twig. Where such twigs remain alive over the winter the leaves produced in the buds on these twigs will always be infected. Fortunately, only a few branches become infested in this way and the majority of these die before the next spring, leaving only a very small percentage of the infection caused by this method even in serious cases.

Control.—Since the great majority of infections take place at the time the buds open in the spring, from spores adhering over winter to the bud scales and twigs, it is obvious that a spray that will kill the spores or prevent

Fig. 42. Twig of the peach affected by peach leaf curl fungus. Note the swollen and distorted branch as well as the affected leaves.

their germination, applied early in the spring before the buds open, will control the disease.

Use the Bordeaux mixture, 5-5-50, or the lime-sulphur 30° Beaume, diluted 1-15, and apply early in the spring just before or while the buds are swelling, but before any of the buds show any green. If any of the buds show even the green tips of the leaves, they may become infected.

Spraying will not prevent infection resulting from the mycelium wintering over in the bark of twigs. Fortunately this method of wintering over accounts for only a small proportion of the infection.

In spraying for leaf curl it is important that every twig be thoroughly covered with the spray.

The general experience of investigators has shown that either of the sprays mentioned are equally good in preventing this disease. Experiments carried out by the Department of Plant Pathology in the spring of 1910 confirm the results of these investigators. From observations made during the spring of 1912 it would seem that the growers had more uniform success when the Bordeaux mixture was used.

California Peach Blight and Fruit Spot.

One of the very important diseases of the peach in Oregon is the so-called California peach blight or fruit spot. The disease has also been referred to as the winter blight. The disease has been quite prevalent for some years in the peach growing sections of the Rogue River Valley, particularly in the vicinity of Ashland. It has also been reported from various sections of the Umpqua and Willamette Valleys and has recently been reported as serious in the Milton-Freewater district of Umatilla County. It seems to be rapidly spreading in the state, but since no thorough survey work has yet been attempted with special reference to this disease, the exact distribution is unknown. It has also been for many years one of the most serious diseases of the peach in the peach growing sections of California where the greater part of the investigations concerning its cause and control have been conducted.

Symptoms.—The most evident symptoms are the dying of the buds on the fruiting wood, accompanied later by a splitting of the bark on the branches of the current year's growth. The buds may die before spring and fail to develop altogether, or they may start and later die after the leaves are well out and the young fruit set. Under the latter conditions the foliage and young fruit die and later fall. Usually associated with the dying of the buds and spots on the twigs is a copious "gumming," which manifests itself in the exudation of masses of gelatinous sap from these spots and from the dead buds. The exudation of gum is most abundant in wet weather, and where the disease is abundant, forms one of the most characteristic symptoms.


Fig. 43. Cankers of Peach Blight on first year growth.

The spots frequently develop into small cankers which may girdle the twigs. These may start on twigs of the current year's growth, as shown in Fig. 43. Similar cankers are found associated with the buds that have been killed. The twigs and branches killed in this way are usually found first in the lower part of the tree. The disease progresses upward and in serious cases only the top branches of the tree may be healthy. This mode of progress of the disease may be related to the fact that moisture is held longer in the lower branches of the tree and hence the conditions for the development of the disease are more favorable than in the upper branches.

On account of the fact that the one year wood in the peach develops the fruit buds, it is seen that the

form of the disease above described is capable of causing almost if not complete failure of the crop.

Constantly associated with the phase of the disease on the twigs, is a characteristic fruit spot and shot-hole effect on the leaves. On the fruit, the spots resemble the effect produced by the San Jose Scale. These are shown in Fig. 44. The spots are at first rather small and purplish red. As the disease progresses the spots become larger and a light colored area develops in the

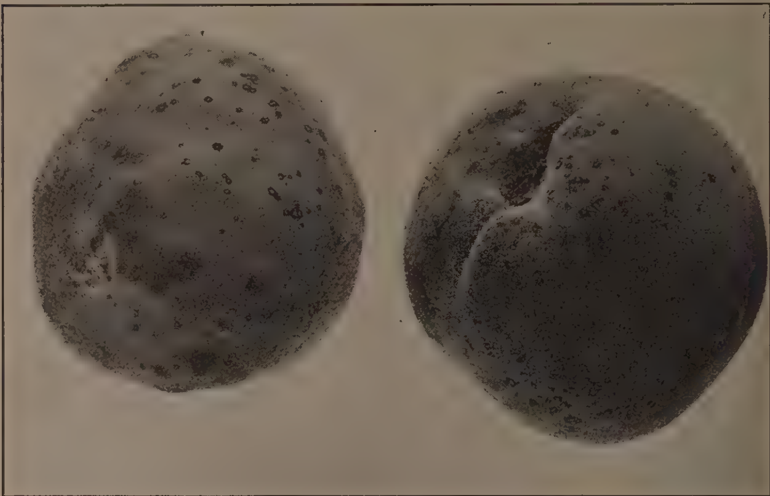

Fig. 44. Fruit affected with the fruit spot stage of California peach blight.

center. Later the spots turn brown and where abundant become confluent. On badly affected peaches cracks may appear and a more or less copious exudation of gum may make its appearance. While inoculation experiments have not yet been carried out to prove that the spots on the fruit and leaves are caused by the same fungus as that which causes the twig blight, it is highly probable that such is the case.

Cause.—Peach blight is caused by a parasitic fungus known technically as *Coryneum beijerinckii.* This fungus is known only in the summer spore stage. A sexual stage, if it exists, has not been certainly associated with this disease. The fungus, which is the initial cause of the dying of the buds, and of the formation of the spots and cankers on the twigs, produces little three or four celled brown spores on the ends of threads from little cushions which break through the outer bark. These cushions are visible to the unaided eye as black spots or pustules. What is evidently the same fungus has been found associated with the fruit spot and shot-hole of the leaves.

Treatment.—The disease became so important in Oregon in 1906, especially the fruit spot form, that Professor A. B. Cordley, with the assistance of Mr. C. C. Cate, undertook spraying experiments for the control of the disease. The work was carried on in the vicinity of Ashland. Spraying experiments were conducted for two years with favorable results and a report made in bulletin 106 of the Oregon Agricultural College Experiment Station. Unfortunately, this bulletin is out of print. The authors determined that the disease can be controlled by fall and spring spraying, and recommend that peaches be sprayed in the fall about November 1. The writer believes the best fungicide for this purpose is the Bordeaux mixture, 6-6-50.

In the above mentioned experiments, lime-sulphur and Bordeaux mixture were used in the spring application; but since more or less injury may result under certain weather conditions, the writer has advised the use of the self-boiled lime-sulphur.*

The mixture should be used in the 8-8-50 formula. The time of the applications for Ashland conditions, according to Cordley and Cate, should be on about the following dates: First, about May 10; second, about June 1. "If the disease has been unusually prevalent, or if rainy weather favorable to the growth of the fungus occurs, the second application may be made about May 20 or 25, and a third one about June 5 or 10." The dates of spraying should be correspondingly later for more northern sections.

In California it has been found that the disease may be kept under control by regular fall spraying with Bordeaux mixture without spring applications. In Oregon the fall application is undoubtedly the most important, but where the disease is firmly established it is probable that spring applications will also be necessary. After the disease is under control, and where fall spraying is regularly practiced, it may later be found that the spring spraying may be dispensed with.

Powdery Mildew.

Powdery mildew is not an uncommon trouble on peaches in the state, though seldom serious. Trees are occasionally so seriously affected, however, that they are unprofitable. Mildew may occur upon the twigs, leaves and fruit. It may appear on the fruit while quite small or during any stage of growth and is characterized by the presence of white frosty spots of mold. At certain stages of growth it has a powdery surface. Sometimes the entire fruit is affected, though commonly only a portion of the surface is attacked. Fig. 45 shows the characteristic appearance of the disease on the fruit. Where

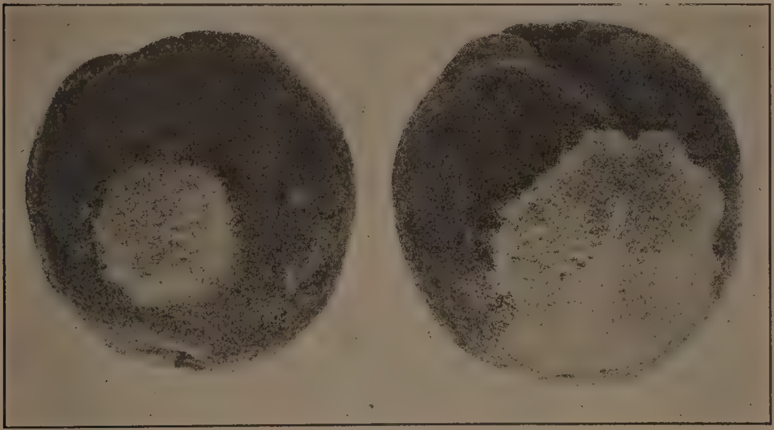

Fig. 45. Powdery mildew on fruit of peach.

it is abundant upon the fruit, the latter is ruined for the market. On the twigs the moldy growth may occur as white blotches. The leaves which are also usually attacked, are covered with a white growth and are usually more or less stunted and curled, and in severe cases fall prematurely. While usually the entire leaf is affected, the mildew occurs also in spots and then appears most abundantly upon the under surface.

*See Circular Bulletin 13, Oregon Experiment Station, for the details of preparation of this mixture.

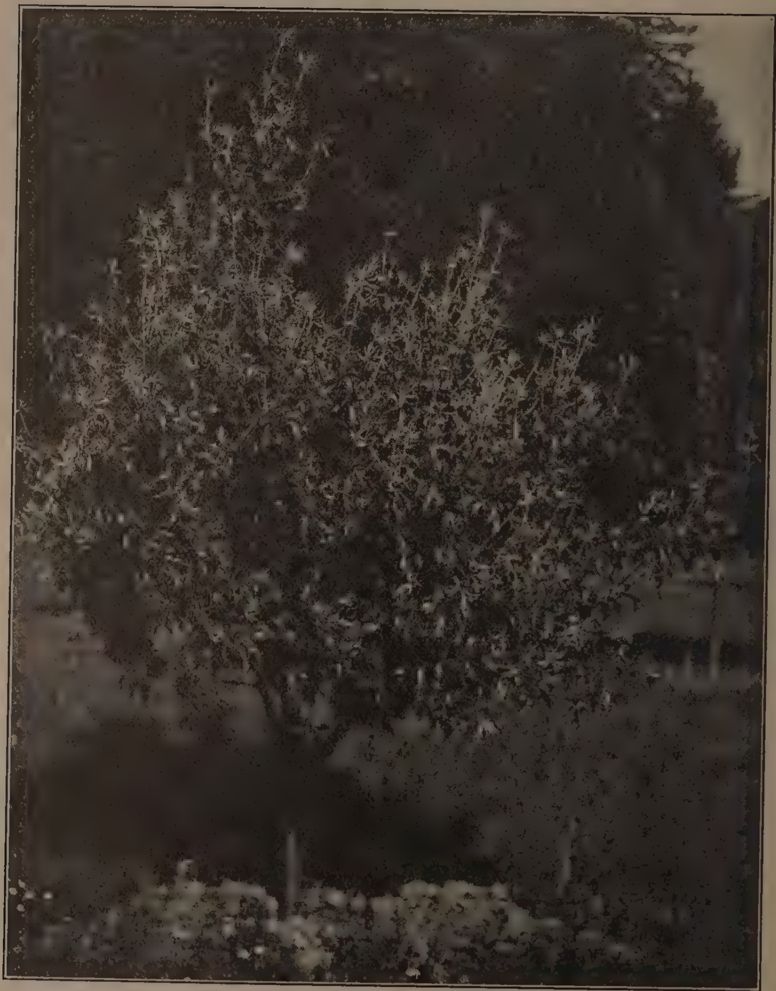

Fig. 46. Peach tree badly affected with powdery mildew in the generalized form.

Powdery mildew on the peach seems to occur in two general conditions. The disease may be scattered on the fruit and leaves, with a few twigs affected; this may be referred to as the scattered form, and is the most common condition of the disease. Occasionally, however, trees are found on which the disease is generally distributed, when practically all the twigs are attacked and the general growth of the tree is seriously interfered with. This may be referred to as the generalized form. See Fig. 46.

In general the disease may be said to be more abundant upon seedlings, though the standard commercial varieties are not uncommonly attacked.

Cause.—Two mildews are reported upon the peach, namely, *Sphaerotheca pannosa* and *Podosphaera oxycanthae*. It is possible that both of these diseases occur in the state and that the scattered form is due to the former species, while the more generalized form is due to the latter. The species of powdery mildews are determined from the characteristics of the perfect stage which develop late in the season as small black bodies in the moldy blotches on the twigs. This perfect stage is seldom produced on the peach and no studies have been made to determine the exact species occurring in Oregon.

Remedy.—Where occurring in the scattered form on a few twigs and the fruit, the disease can doubtless be held under control by the methods described for the spring treatment of California peach blight or for the brown rot. Where the disease attacks a tree in the generalized form, it is very difficult to control, and ordinary spraying methods, according to our observations, have not been successful. In many cases such trees are found to be seedlings and should be taken out. If this condition occurs upon standard varieties, severe cutting back followed by thorough spraying should be tried as a remedy. It is suggested that the grower combine the recommendations given for California peach blight in the fall and for peach leaf curl and brown rot in the spring.

PRUNE DISEASES.

Brown Rot.

This is one of the most serious fungous diseases of the prune in Oregon, and during some years causes considerable loss, particularly in the Willamette and Umpqua valleys. It is more abundant in seasons of frequent summer rain. This disease is discussed fully on page 248.

Crown Gall.

The disease known as crown gall is not uncommon on the prune, both when grafted on peach or prune roots. The reader is referred to a general discussion of crown gall on pages 218 to 226 of this report.

Mushroom Root Rot.

In some sections of the state, notably in the northern part of the Willamette Valley, mushroom root rot is very serious upon the prune. A special article on this disease will be found on page 226.

Rust.

A true rust of the foliage of prunes is not uncommon, though it is seldom present in sufficient amount to be considered serious. This disease is caused by a fungous known technically as *Tranzschelia punctata*. It is most abundant late in the season and when serious may cause a premature falling of the foliage. The disease is also known to attack the peach, plum and other related trees. The disease may be recognized by the appearance of small dusty brown or black sori on the under surface of the leaves. On the upper surface yellowish spots appear. It is probable that under Oregon conditions, should the disease become serious enough to warrant special remedy, Bordeaux mixture applied in the middle of August or first of September would control the disease.

DISEASES OF NUT CROPS.

By H. P. BARSS.

WALNUT DISEASES.

Bacteriosis or Bacterial Blight.

In view of the importance which walnut culture is rapidly assuming in Oregon, attention should be called to the presence in the state of the bacterial blight, to which nearly all the cultivated varieties are susceptible. The disease is quite widespread, but has not attracted great attention through the state, because few of our commercial walnut orchards have yet come into full bearing. In California this trouble causes very serious losses in many localities, especially during seasons when there is an unusual amount of damp, cloudy weather late in the spring. Although the loss has often been great, it is reported that even in badly infested districts the damage has usually been insufficient to make walnut raising unprofitable. We find that in Oregon in unusually moist seasons the attacks of bacteriosis are quite serious in several localities, although little complaint regarding the disease is at present received in ordinary seasons. In western sections, however, where the rainy weather usually continues later in the spring than it does in California, it seems possible that, as the cultivation of the walnut becomes more general, our crops may suffer even more than those in the neighboring state.

The Nature of the Disease.—The disease is caused by the bacterium, *Pseudomonas juglandis*, and infection is to some extent brought about by insects that carry the germs from diseased to healthy shoots, nuts, etc. On the leaves the organisms produce black spots; young twigs and fruit spurs are also often killed back, with attendant black discolorations, while sometimes small cankers are formed. The greatest damage, however, is due to the attacks upon the nuts. (Fig. 47.) Upon the surface of the young nut there appear small, black, somewhat irregular spots which spread, often coalescing, until sometimes the larger portion of the nut may become blackened and

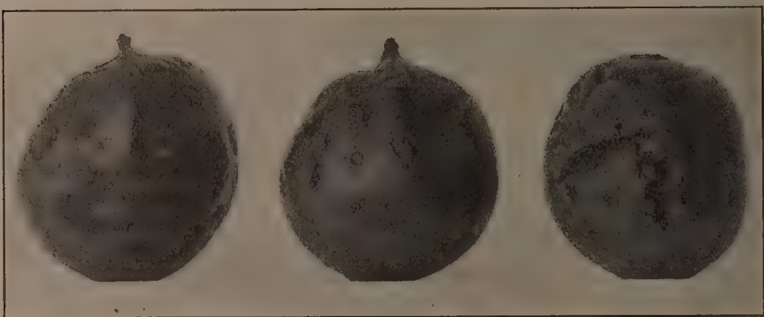

Fig. 47. Walnut affected with walnut blight, slightly reduced.

shrunken. Many of the spotted nuts drop prematurely, while most of the remainder are ruined by a black decay of the meat. Often the interior of the nut is badly rotted where on the outside only a small diseased spot is visible. As has been intimated, moist weather conditions are favorable to the spread of the disease, whereas bright and dry weather checks the infection.

Control.—On account of the bacterial nature of the blight, control is difficult. Experiments conducted in California for a number of years indicate that spraying has only slight value as a preventive, while the size of the trees and the time and expense required to coat them thoroughly, render such a method impractical. It has been found, however, that there is great variation

in the comparative blight-resistance of different varieties of walnuts. It is in the direction of securing resistant varieties, therefore, that we find the most hopeful outlook for avoiding the ravages of bacteriosis in future plantings. The California Experiment Station has found that late-blooming varieties suffer to a less extent than those which set fruit early, while the weather is still damp. Such French varieties as the Mayette and Franquette are rather resistant under California conditions, while certain local seedlings of foreign varieties, among which may be mentioned the Eureka, Concord, Chase and San Jose, are reported as still more successfully blight-resistant. No tests of comparative immunity have yet been made under Oregon conditions; but it seems probable that varieties recommended as immune to the disease in California will also prove superior in this respect to other varieties when grown in Oregon.

In general, we would recommend budding or grafting upon hardy stock, like the California Black Walnut (see Circular Bulletin 16, Oregon Experiment Station, 1911), avoiding the use of varieties known to be badly susceptible. Thorough cultivation is also advised, as the increased growth and productiveness will partially make up for any loss due to the disease.

Crown Gall.

It is reported that the English walnut is occasionally attacked in certain places on the Pacific coast, by a disease similar to the crown gall of fruit trees caused by *Pseudomonas tumefaciens*. A general description will be found on page 218.

Mushroom Root Rot.

The English walnut has been found in one district of Oregon affected with mushroom root rot. It is not known just how widespread or serious this disease is in the state, but since it is also reported as not uncommon in California, it is probably more prevalent here than has been supposed, and growers are advised to watch for its appearance. A description of this disease appears on page 226 and what is said with regard to its appearance on other trees will apply equally well to the disease on the walnut.

DISEASES OF SMALL FRUITS.

By H. S. JACKSON.

DISEASES OF CANE FRUITS.

Anthracnose of Raspberry, Blackberry, Loganberry, Etc.

The disease known as anthracnose is a very common trouble of certain varieties of blackberries and raspberries throughout the United States; and in Oregon, at least, the disease is becoming serious upon the loganberry as well. This is apparently an American disease, first described by Burrill in Illinois about 1882, and has often been referred to as causing considerable loss in various sections of the country. It is probably the most serious disease with which the loganberry grower is likely to have to deal; and in most sections spraying for this disease will doubtless become a regular operation in connection with the culture of this fruit.

The disease attacks the canes, leaves and the fruit. On the stems the disease produces spots of varying size and color, depending upon the variety attacked. The spots are pale in the center with irregular brown and black (or on the raspberry particularly, purple) margins. Fig. 48 shows the characteristic appearance on canes of loganberry. The spots may run together, forming long irregular patches of diseased tissue. On the leaves small spots are produced with pale centers, but with rather broad reddish or purple bor-

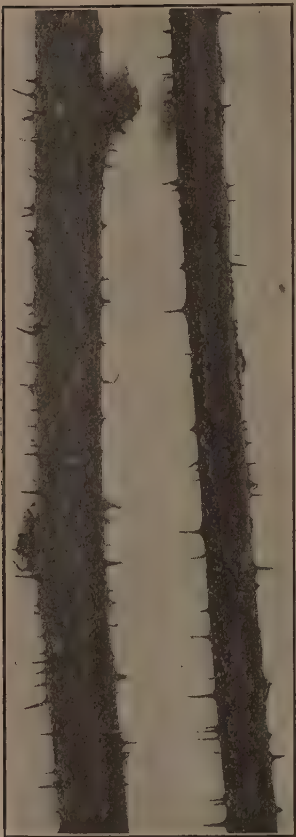

Fig. 48. Anthracnose spots on Loganberry canes.

ders. (Fig. 49.) On some varieties the diseased area may drop out and give more or less of a shot-hole effect. On the fruits the drupelets are found to be affected, the fungus spotting the individual drupelets. These may be attacked when about half ripe or later. The disease on the fruit has been reported as particularly serious on the Snyder blackberry and on the loganberry.

Cause.—This disease is due to a fungus, *Gloeosporium venetum*, which, growing in the tissues of the plant, produces the spotting described above. The fungus is reproduced in the spots by the formation of many minute spores, in a manner similar to that described for apple tree anthracnose. These spores are disseminated most abundantly by wind and rain. Under favorable conditions spores are produced in great numbers and the disease may spread rapidly over the field. No winter stage has been recorded for this fungus, and it is probable that the summer spore stage may live over on the dead leaves or canes or in the spots on the living canes.

Prevention.—Experience has shown that proper precautions in regard to sanitation have a very important bearing upon the control of this disease. All fruiting canes should be removed as early as practicable after the fruit is picked. These should be removed from the field and burned, preferably before all leaves fall. In trimming out the patch in the fall one should also prune out any seriously affected canes of the current year's growth. The removal of the canes of the current year's growth might be delayed till early spring on account of the danger of winter injury, but if this is practiced then they should be protected, as suggested below, by a fall application of spray. There seems to be considerable difference in the susceptibility of varieties to this disease, and where possible, resistant varieties should be grown. The experience of investigators regarding spraying for this disease has not been uniformly successful; but it seems probable from experiments conducted by Lawrence that three sprayings in the spring will go far towards controlling this disease in the Northwest. Bordeaux mixture should be used in the 4-4-50 or 5-5-50 formula.

Spray, first, before the leaves appear in the spring, covering the canes thoroughly; spray again as soon as the leaves are well out and the young shoots are about six inches in height; spray a third time just before the plant blossoms. Where loss due to infection in the fruit is experienced, it may be found desirable to spray when the fruit is half to three-fourths grown. In this case the use of some spray mixture such as the Ammoniacal Copper Carbonate or Bergundy mixture may be found desirable; since such sprays leave no deposit on the fruit. Where the disease is particularly serious and spring spraying has not been entirely successful an application of Bordeaux mixture about the middle of August or first of September, before the fall rains begin, might prove advisable, because it would doubtless prevent a large part of infection which occurs upon the canes and leaves in the fall. Since very little experimentation for the control of this disease, particularly on the loganberry, has been carried

on under Oregon conditions, the above remarks on spraying should be considered as suggestive rather than as definite recommendations. It is hoped

Fig. 49. Loganberry leaf showing spots caused by anthracnose.

that careful experiments may be carried out by the department of Plant Pathology at an early date.

Mushroom Root Rot.

The trouble known as mushroom root rot, which has attracted so much attention as a disease of apples and prunes in some sections of the Northwest, is known also as a disease of cane fruits. This disease has been reported as a serious trouble on cane fruits only in the Northwest. A general account of this trouble will be found on page 226 of this report.

Crown Gall.

The disease known as crown gall or root knot is a common one on a large number of trees and small fruits as well as upon many herbaceous plants.

On the cane fruits crown gall is known particularly as a serious disease of the loganberry, blackberry and raspberry.

A general discussion of this disease with suggestions for avoiding it will be found on page 218 of this report.

Raspberry Cane Blight.

The cane blight is a serious disease of the black and red raspberry and is known to attack other berries as well. It was first described as a serious disease by Stewart, of the State Experiment Station of New York. Since that time it has been recorded in a number of sections of the country. It is reported as causing serious damage in southern Oregon and, no doubt, occurs in other parts of the State, though complaints from growers have not been frequent.

Symptoms.—The disease is characterized by a wilting of affected canes. It is common as a disease of the fruiting canes, though canes in the first year of growth may be attacked. The entire cane may be wilted, or only a part of it. If the cane is closely examined a diseased area of tissue will be found at the base of the wilted portion. The bark of diseased canes is lighter in color than is normally the case. The disease commonly starts in stubs exposed in pruning. It is probable that most of the infection occurs in wounds.

Cause.—The disease is caused by a fungus known as *Coniothyrium fuckelii*. This fungus grows in the tissues of the stems and causes the death of the tissues and the consequent wilting of the canes. The reproductive bodies or spores are borne in minute receptacles in the discolored areas found at the base of wilted canes or portions of canes. The surface of the bark is often smoky black, due to an abundant production of spores. The disease doubtless lives over winter on old canes or pieces of canes left in the field and probably on the bases of old canes after pruning.

Control.—The disease is doubtless disseminated through nursery stock; hence, the purchase of stock for planting from diseased plantations should be avoided. Every effort should be made to obtain healthy stock for planting, and new plantations should not be put out where berries have been grown at all recently, since it is probable that the disease may remain in the soil on old pieces of canes for a considerable period.

Most careful sanitary measures must be practiced in the field. The old canes or diseased young canes should be removed and promptly burned immediately after picking is over. Old and diseased canes should be cut close to the ground.

Where the disease is serious a dormant spray should be given. Use Bordeaux mixture 6-6-50, to which has been added a resin "sticker." It has also been recommended to spray twice with the same mixture using the 5-5-50 formula when the plants are in foliage. The first application should be made when the young canes are 6 to 8 inches in height. The second, just before the blooming period. Finally, an application should be made in late summer, just after the old canes have been cleaned out.

GOOSEBERRY DISEASES.

Powdery Mildew.

This is the most serious fungus disease which is known to attack the foliage and fruit of the gooseberry. It is a native disease; that is, due to a fungus which doubtless occurred upon wild gooseberries before cultivated varieties were planted in this country. It is found to be much more serious upon European varieties than American varieties. It is probable that varieties originating from European species, not having this fungus to contend with, have never developed any natural immunity. This disease is present in more or less severity in all parts of the United States where gooseberries are grown.

Fig. 50. Gooseberry attacked by the powdery mildew.

It was introduced into Europe about 1900, and spreading rapidly, has become so serious that, in some localities, the growing of gooseberries has been temporarily abandoned.

Symptoms.—This disease is characterized by the production of a superficial white mold or mildew in spots on the fruit and foliage of young canes. (Fig. 50.) It probably first starts upon the young foliage, but is first noticed by the grower upon the fruit. The spots are at first whitish but later become buff or almost brown in color. From the fruit the disease spreads rapidly to the foliage and young canes. If examined with a pocket lens the spots, when young, are seen to consist of a white cob-webby growth. Several spots may grow together and large patches may be formed. In older spots the moldy growth turns brown. Later in the year small black specks, just visible to the unaided eye, appear in the brown mold in older spots.

The berries, when attacked on one side, may develop unevenly, and in severe cases may crack and decay. When attacked at a later stage they do not crack; but the presence of the mold renders them unsalable.

The leaves of diseased shoots are small and where badly affected gradually turn brown. The general effect on the plant is to reduce the vitality, and market value of the crop.

Cause.—This disease is caused by a fungus belonging to a group known commonly as the powdery mildews. These fungi are superficial in their growth; that is, the mycelium develops largely on the outside of the affected spots instead of in the tissues as is the case with most fungi. The mycelium sends short branches into the outer cells of the part of the plant attacked. These absorb the sap. In the early part of the season the summer spores are produced in chains on the erect branches of the mycelium. These are produced in great abundance and soon fall apart, giving the surface of the spots a dusty appearance, from which fact the name "powdery mildew" has originated. These spores are easily spread by the wind or other agencies and start new spots wherever they come to rest. This superficial mycelium, as noted above, soon turns dark and becomes thick-walled. and later in the season black spherical receptacles are formed which have long thread-like appendages attached. These are called perithecia, they are hollow and enclose a single large sack or ascus, inside of which is found eight rather large spores. This stage, which may be referred to as the winter spore stage, serves to carry the fungus over winter. The perithecia, when mature in the spring, burst, forcibly ejecting the spores, which, on coming to rest upon young leaves or fruit, germinate, causing the first spots. It is thus seen that the fungus, which remains over the winter on the canes of the current growth and on the leaves and ground, etc., serves as a source of infection in the spring.

Treatment.—This disease is one of the most difficult among the powdery mildews to control. The standard remedy for years has been to spray with potassium sulphide, 1 ounce to 2 or 3 gallons of water, beginning when the buds break open and continuing at intervals of ten days until about seven applications have been made. This, wherever used thoroughly, has been found to control mildew.

Co-operative experiments conducted by the writer in Oregon during the past season indicate that an application of winter strength lime-sulphur to the dormant branches, followed by applications of lime-sulphur diluted 1-30 on the foliage at frequent intervals gives excellent satisfaction. On account of the slight deposit of lime-sulphur it may be found desirable to use potassium sulphide in the later sprayings.

CURRANT DISEASES.

Anthracnose.

Current anthracnose seems to be the most common fungous disease of this fruit which occurs in Oregon. It seems to be widely distributed in the State and is generally known throughout the United States. It is also common in

Europe. This disease is known to attack the gooseberry, but usually not in a serious form, and has not yet been observed upon this crop in Oregon. It is more severe upon the red and white currants than upon the black. There is doubtless considerable difference in the susceptibility of the varieties, but no data of value has yet been brought together on this point relating especially to conditions in the Northwest.

Symptoms.—The disease is primarily a leaf disease, though it may grow upon practically all parts of the plant above ground, including the fruit. On the leaf the disease causes small brown spots which are more or less thickly scattered. When abundant the affected leaves turn yellow and fall. This disease is probably the cause of much of the premature defoliation of currants which occurs in the State. The general effect of the fungus is to interfere with the proper development of the fruit and generally to reduce the vitality of the plants, thus interfering with the proper ripening of the fruit and the formation of the fruit buds for the next year. Spots of the disease may also occur upon the petioles and young canes and upon the fruit stalks and young fruits. Conspicuous black spots which are slightly sunken are formed on the leaf stalks and petioles and also on the fruit stems. Here the spots are black and from one-fourth to one-half inch long. On the fruit black spots resembling fly-specs are formed.

On the young canes the disease produces only a slight discoloration; it occurs only upon young canes of the current year's growth, and is very difficult to detect.

Where plants are in partial shade they are not as seriously attacked. Older plantations are found to be more seriously affected than more recent plantings.

Cause.—This disease is caused by a fungus known technically as *Pseudopeziza ribis*. The fungus exists in two spore stages. In the spots on the leaves, petioles and canes, the summer spores are produced in peculiar fruiting structures known as acervuli; these are doubtless disseminated by wind and spattering rain, and when coming to rest upon any part of the plant grow into the tissues and cause new spots. This spore stage is called the conidial or summer spore stage.

On the diseased leaves which fall to the ground in the fall, another spore stage of the fungus is formed. This is produced from the mycelium of the summer spore stage which spreads in the dead leaves, but is of quite a different character. Little cushion-like fruit bodies are produced inside the tissues of the leaf which finally spread out upon the surface. They are visible to the unaided eye. The surface of these cushion-like bodies when mature is covered by a layer of sacks called asci, each of which bears eight spores. These mature about the time the plants leaf out in the spring. Spores ejected from the asci and carried by the wind to the young leaves of currant plants, cause the first spots of this disease which appear in the spring. This fungus is particularly interesting on account of the fact that the life history and structure of the fungus show that it is very colsely related to the one which causes the disease known as apple tree anthracnose.

It has been proved also that the summer spore stage matures on the stems, and it is possible that the fungus winters over on the canes in this condition.

Treatment.—Since the first infection results from the dissemination of the sexual spores from the dead leaves of the previous season, any method of destroying these leaves might tend to reduce the seriousness of the attack. It would be advisable, therefore, to plow early, before the leaves come out in the spring, in order to bury the dead leaves. Where practicable, raking and burning the leaves would have the same result and would probably be more effective. A dormant spraying toward spring, to prevent any further development of the summer spores on the canes, would be advisable. Use the Bordeaux mixture 5-5-50. Spray again when the leaves unfold and repeat at intervals of ten days until the fruit is two-thirds grown, avoiding the blossoming period. If summer rains are abundant it may be found profitable to spray once or twice after the fruit is gathered.

STRAWBERRY DISEASES.

Leaf Spot.

The only fungus disease of the strawberry occurring in Oregon that has been thoroughly studied by Pathologists is the disease known as the strawberry leaf spot or blight. This disease is nearly always present to a greater or less extent in every field. It is not always serious and, in fact, is rarely considered by Oregon growers to cause sufficient damage to need special treatment. In many cases, however, it causes more damage than is realized, and hence is considered of sufficient interest to warrant a discussion in this connection. All of the cultivated varieties may be attacked, though many are so resistant as not to be seriously affected.

The disease affects the foliage primarily, making its first appearance on the plants as minute purplish spots more or less thickly scattered. (See Fig. 51.)

Fig. 51. Strawberry leaf showing spots caused by the leaf spot fungus.

These soon enlarge and the center becomes pale gray or nearly white in color. The margin, however, remains purple, shading into brown towards the lighter area in the center. When numerous these spots may run together. In severe cases the leaves may gradually turn yellow, wither and die. In certain instances the disease has been reported as being so severe that the plants are killed, though this has never been observed by the writer in Oregon.

Cause.—This disease is caused by a fungus known technically as *Mycosphaerella fragariae*. The mycelium grows in the tissue, killing it and forming the characteristic spots. This fungus has two sorts of spores. Conidia or summer spores are borne on special threads of the mycelium which emerge from the tissues through the epidermis in tufts. These are produced during the summer, serving to disseminate the disease through a field. Another spore stage known as the sexual, ascigerous, or winter stage, may be produced later in the season. In this stage the spores are borne in sacks, several of which are found inside receptacles imbedded in the tissues. These are only

found late in the season and are believed in general to serve the purpose of carrying the fungus over the unfavorable conditions of winter. In Oregon the fungus seems to spread all winter and it is possible that the summer spores are sufficient to keep the fungus perpetuated.

Control Measures.—Only healthy plants should be set. Plants should be secured, if possible, from fields where the disease was not present. In any case all diseased leaves from plants should be picked off before planting. Cutting and burning the foliage after harvesting the fruit, as carried on in some sections of Oregon, is an excellent practice, since it destroys many leaves affected with the disease. When the disease is severe, spraying may be practiced. Use Bordeaux mixture 4-4-50. In Oregon three sprayings are suggested for trial, two in early spring before the first fruits are half grown, and another about the first or middle of September.

GRAPE DISEASES.

Powdery Mildew.

The only important fungous disease that is of special interest to grape growers in the Northwest at the present time is the disease known as the powdery mildew. This is most serious on the European varieties and consequently is of special interest in California and those sections of Oregon where these varieties are grown.

Symptoms.—The disease may attack any herbaceous part of the vine. On the leaves the fungus appears in the form of white or greenish white patches of mildew. These may run together till the greater part of the leaf is covered. The fungus may also attack the young canes, beginning at the base in the form of small patches; or in severe cases the whole surface may be covered. The green or white mildew is easily rubbed off, leaving on the canes brownish spots which soon turn black. If severely attacked the canes fail to grow or mature properly. When the disease attacks the blossoms they fail to set. If the young fruit is attacked when quite small the berries may drop off. If attacked when half grown they develop irregularly and the affected parts become hardened, the ripe berries becoming irregular in form. If severely affected they may crack, thus becoming useless for table or market use. If this cracking is early they may still be used for wine, though in moist seasons they may be attacked by various molds. The berries are usually not attacked after they begin to ripen. When only slightly affected the berries may ripen without cracking, but are disfigured by spots or blotches which reduce their value for market purposes.

Cause.—The cause is a fungus known technically as *Uncinula spiralis*. This, like all fungi commonly known as powdery mildews, grows more or less superficially on the surface of the affected parts. The fine thread-like mycelium is largely external, sending short feeding branches into the epidermal cells of the host. From this superficial mycelium erect branches are formed which break down into short cells or spores. When abundant these give the spots the powdery appearance that accounts for the popular name of this and other related forms. These spores are spread by the wind and thus may come to rest on a healthy part of a vine. They germinate by putting out a thread of mycelium which branches and attaches itself to the surface of the host and grows into a fungous plant which, when it has reached its full development, produces spores in countless numbers like that from which it grew. This stage, which is known as the summer spore stage, serves to spread the fungus rapidly.

Later in the season another form of the fungus, sometimes spoken of as the winter or resting stage, is produced. This consists of closed globose structures borne on the mycelium and having peculiar spiral tipped thread-like appendages attached to the surface. These bodies called perithecia, are just visible to the unaided eye, while the appendages mentioned above may be made out with a good pocket lens. Inside these perithecia spores quite different in character from those described above, are borne in numerous little sacks. The perithecia protect the spores till spring, when they rot away or

become broken in some way and set the spores free. It is from the germination of these spores on the vines that the first new infections of the summer spore stage start in the spring.

Treatment.—Where this disease is serious enough to cause any amount of loss the vines must be protected by some fungicide. It has been found that the best method is to dust the plants with dry sulphur. The fungicidal value of dry sulphur rests largely in the vapors which are given off during hot weather (above 75°). Below this temperature the fungus does not grow well. If the vines are covered with a sulphur dust and the temperature rises above 75° F., the sulphur is volatilized and prevents the growth of the fungus.

The vines may be dusted either when dry or wet with dew. They should not, however, be very wet. An application should always be made when the blossoms begin to open. In some sections this is sufficient; in others, a previous application when the vines are about six to eight inches long should be made. Sometimes three or four dustings are necessary. The vines should be carefully watched and when any signs of mildew are detected an application of the sulphur dust should be given to prevent its spread.

Any method of application by which the herbaceous parts of the vine are completely covered with a very fine coating of sulphur dust may be used. The most efficient method is by the use of some form of hand or knapsack duster, several forms of which are good. The best are of European manufacture.

Mr. A. H. Carson, Commissioner of the Oregon State Board of Horticulture and a prominent grape grower at Grants Pass, in a letter dated Sept. 17, 1912, gives the following information concerning his experience in regard to the control of powdery mildew under Oregon conditions:

"For controlling the mildew, we use the best brand of fine sublimed sulphur. The first sulphuring is done when the grapes first bloom. It is important to sulphur at this time, as there is an invisible mildew that attacks the bloom, and if sulphured at this time the grapes will set much heavier than if not sulphured. The vines should again be sulphured when the grapes have formed about the size of a BB shot. If the season is normal, not too much rain, it will not be necessary to sulphur again until the grapes begin to show color, then a third sulphuring should be done.

No grape grower need fear the mildew if sulphur is used at the time of growth as I have indicated above. Sulphuring the vines as I have indicated is a sure preventive of the mildew, but, should the mildew develop among any of the vines before sulphuring, you cannot stop it on the vines that it has developed on, but you can prevent it spreading to healthy vines. The best sulphuring machine I know of is the Torpille Vermorel, made in France, H. C. Shaw Co., Stockton, Cal., sole agents for the U. S. The machine costs $15.00 f. o. b. Stockton. One man with this machine can sulphur from ten to twelve acres in ten hours. For a small vineyard, sulphur shaken on the vines from a gunny-sack will give results."

Crown Gall.

The disease known as crown gall or black knot of the grape is not uncommon in the Northwest, and in some localities is becoming so serious as to cause considerable loss to growers. (See Fig. 20A.) The disease is widely distributed in this country and abroad, but occurs in its most serious form in those regions where European varieties of grapes are grown. This disease is discussed fully on page 218.

DISEASES OF VEGETABLE CROPS.

By F. D. Bailey.

CABBAGE DISEASES.

Black-leg or Phoma Wilt.

This is a serious disease of cabbage and cauliflower. Though it has only recently been reported in the United States, it has already become widely distributed. In Ohio many fields have been seriously damaged, in some, indeed, the disease was so severe that no marketable cabbage were cut. It is supposed that this disease was introduced from Europe where it has caused severe losses, especially in France, Germany and Holland. It has been known

in Australia for a number of years and is thought to be the most serious disease affecting cauliflower and cabbage in that country. This disease has been found in Oregon, during the season of 1912, in Jackson and Wallowa counties. In the latter, where it probably appeared the previous year, it is already causing alarm. It is very probable that the fungus may be introduced on seed, and it is interesting and possibly significant to note that the Wallowa grower purchased his seed from Illinois the year he first observed the disease.

Symptoms.—The most characteristic symptom of this disease is the blackening and decay of the stem close to the surface of the ground. (Fig. 52.) Cankered areas are produced which sometimes completely girdle the stem and the plant is often broken over by the wind. The outer leaves of affected plants are bluish red in color, a characteristic which remains until the plant dies. Plants may be attacked at any time in their growth, more often, however, when they are about one-half grown.

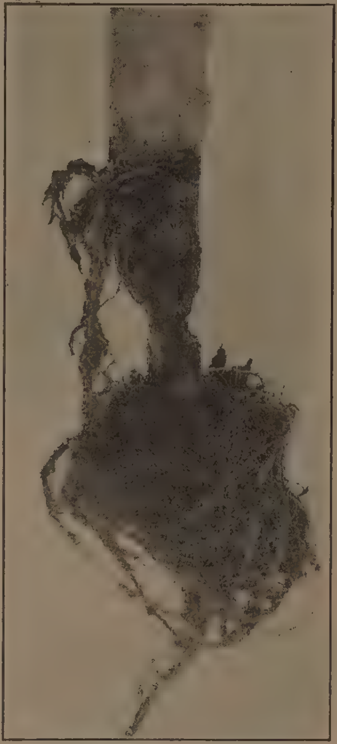

Fig. 52. Black-leg of cabbage. The stem is often girdled near the surface of the ground.

Other symptoms are spots on stem and leaves, in which numerous very small black specks can be seen. A wilting, in which the leaves droop instead of falling off, is frequently observed in diseased plants.

Cause.—The fungus which causes black-leg of cabbage and cauliflower is known technically as *Phoma oleracea.* It enters the plant at some place near the surface of the ground, probably in wounds made by insects. Leaf infection may also take place. From these infected spots the fungus spreads, killing the plant tissue and shutting off the food supply from other parts. It comes to the surface to form the pycnidia or small black specks in which great numbers of minute spores are produced. These spores are forced to the surface and are carried by wind, water, insects or other agencies, to start new infection. Many seedlings are infected at planting time. If an occasional diseased seedling is handled, spores will be transmitted to the hands and later to healthy plants. The disease is frequently found closely associated with the wounds and injuries of insects, though infection may take place without aid from this source.

Treatment.—The black-leg organism is doubtless carried over in the stems and leaves of old decaying plants. It is a fungus capable of living in the soil, but one that can be controlled if the proper measures are constantly employed. The greatest care should be taken to keep the seed bed free from it, thus making certain that it does not become distributed over the fields. The recommendation is made in Ohio that the seed beds be sprinkled with 4-4-50 Bordeaux at the time of planting, using one gallon of the mixture to each 10 square feet. This operation should be repeated two weeks before transplanting and again just before transplanting. This method has proven effective in holding the disease in check. It is better to select clean ground for the seed bed each year and disinfect the seed to be used. A safe treatment for cabbage and cauliflower seed is to use a solution of formalin, one-fourth pint in seven gallons

Fig. 54. Club root on turnips.

Fig. 53. Cabbage plant affected with club root.

of water, allow them to soak for 15 minutes, rinse in clean water and spread out to dry.

When the disease appears in the field the affected plants should be removed and burned.

The truck growers of the Northwest may well be on the lookout for this disease. It must be dealt with intelligently from the first, for, once established, the disease is a difficult one to control. Try the "ounce of prevention."

Club Root.

This is a destructive root disease of crucifers attacking, among the cultivated crops, the cabbage, cauliflower, turnip, etc. It is caused by a very minute organism belonging to the group Myxomycetes, commonly referred to as the slime moulds. The technical name of the organism causing this disease is *Plasmodiophora brassicae*. This disease occurs in various sections of Oregon but cannot be considered to be a very common trouble. The knotty swellings or club-shaped enlargements (Figs. 53 and 54) resulting from the invasion of roots by this fungus prevent the normal growth of head or root and gradually kill the plant.

When once established in the soil, the fungus will live for several years. Certain weeds, shepherd's purse and hedge mustard, are good hosts and doubtless furnish opportunity for the disease to perpetuate itself and to spread.

Control.—Care must be taken to keep the seed beds clean. Destroy all refuse from diseased plants. Do not allow such material to get into the compost heap. Practice rotation with crops not included in this group of plants, and keep the weeds down. Experiments have shown that an application of lime at the rate of about 100 bushels per acre when the land is plowed in the spring is a reliable method of control.

CELERY DISEASES.

Late Blight.

The disease commonly known as late blight of celery seems to be the most serious disease of that crop in Oregon. It is commonly found in most parts of this country where celery is grown. It also occurs in Europe, and by many is believed to have been introduced into this country, probably through seed. There is a possibility, however, that a similar disease is present on some native weed of the celery family and has spread to the cultivated varieties of celery.

This disease occurs in the plants in the form of spots on the blade of the leaf, though the disease may attack the leaf bases. The spots are small, irregular in outline, and tawny in color (Fig. 55). These spots are caused by a fungus known as *Septoria petroselini*, var *apii*. If examined with a hand lens, numerous small black specks which are slightly raised may be seen scattered irregularly in the spots. These are the pycnidia, small pear-shaped receptacles imbedded in the tissue of the diseased spots. They contain the reproductive bodies or spores of the fungus, which are long and thread-like in character. These spores escape through a minute opening present in the pycnidia, and, being scattered by wind and rain, cause the growth of new spots. The spots may appear on the first leaves of the seedlings in the seed bed, a fact which suggests the possibility that the disease may be carried through the seed. It has been shown by Beach that the pycnidia may form on the seed coats.

When the fungus is abundant on the leaves, and especially on the leaf bases, there is a tendency to make the stalks brittle, so that minute transverse cracks are formed which reduce the market value.

Usually the spots are clearly defined, but under favorable conditions for the development of the fungus, the entire leaflet may be affected and the pycnidia scattered over the whole area, resulting in a complete wilting of the leaves.

The disease may also develop seriously in storage, particularly if the storage houses are too warm or are poorly ventilated.

It is probable that the disease lives over winter in the dead leaves that are left in the fields at digging time.

Fig. 55. Leaf spot or late blight of celery.

Remedy.—It is advisable, so far as practical, not to trim the plants in the field. Diseased plants and leaves should not be thrown in the compost heap if the compost is to be used as fertilizer for celery beds or fields. It is also advisable, where possible, to practice a three or four year rotation of crops.

Spraying must be practiced as a preventive. The seedlings should be sprayed frequently (at least once a week), beginning when they show the first leaves. The plants should be sprayed in the field often enough to cover new foliage, and especially after every heavy rain. Bordeaux mixture should

be used in the 4-4-50 formula. Ammoniacal copper carbonate may be used for the later sprays in the field, as this mixture does not leave a deposit on the plants.

The practice of overhead sprinkling, as practiced by many Oregon growers, is especially undesirable as this has the same effect as frequent rains and offers ideal conditions for the development and spread of the fungus. Where irrigation is necessary, arrangements should be made to apply the water in rills.

LETTUCE DISEASES.

Downy Mildew.

This disease is caused by a fungus *(Bremia lactucae)* which in its life history is similar to the fungus causing the onion mildew (page 276). This disease occurs, in general, only under certain conditions favorable to the growth of the fungus. It occurs in the greenhouse or in forcing frames which are kept too warm or moist and may ordinarily be controlled by properly regulating these conditions.

Symptoms.—It is recognized by yellow areas on the upper surface of the leaf and by the white downy growth of the fungus on the lower surface.

Control.—It is advisable to burn diseased leaves or plants and water the beds in such a way that the foliage is kept dry.

Drop.

The fungus causing this disease *(Sclerotinia libertiana)* occurs on many different kinds of plants, and since it is a common soil organism of a type that is hard to control should be carefully guarded against. The affected plant shows no definite diseased spots. It grows slowly, finally the stem and lower leaves become watery and soon the whole plant collapses and rapidly decays.

Control.—It is claimed that the disease can be eradicated from a bed in two years if all diseased plants are removed and destroyed as soon as they appear and the place is immediately drenched with Bordeaux mixture or a solution of bluestone. This is necessary in order to prevent the sclerotia or resistant stage of the fungus from maturing. In some cases it may be easier to change or sterilize all of the soil in the bed. The disease can be held in check by the careful regulation of temperature and water supply. A low night temperature with constant day ventilation is very essential.

Gray Mold.

This disease is due to a common fungus *(Botrytis cinerea)* and is in all essentials like the "Drop." After the plant has collapsed, a gray mold appears and at this stage great numbers of spores capable of spreading the disease are produced. The same control measures apply as for "Drop."

Damping Off.

This trouble is caused by a soil fungus frequently called Rhizoctonia and known technically as *Corticium vagum*. This fungus, which is widespread, is capable of causing damping off diseases in many different kinds of seedlings and plants. In its attack on lettuce it may either "damp off" the young seedlings at the surface of the ground or, if it attacks older plants, it may produce the rosette. This condition is characterized by the failure of the center leaves to grow.

Control.—Either steam sterilization of the soil or a treatment with formalin has been found effective. In sterilizing with formalin, use a 5% solution of the 40% formaldehyde in water and drench thoroughly. Allow soil to dry before setting plants.

Leaf Perforation.

This disease *(Marsonia perforans)* has recently been found in greenhouses in several localities in the state, and as it has caused considerable damage in

Ohio, where it was first discovered, it seems advisable for the growers to be on the lookout in order to hold it in check.

Symptoms.—On the leaves this fungus causes spots which die and drop out. On the midrib, many sunken, elongated spots are produced. A plant once affected, seldom ever recovers and the new leaves are misshapen and unsalable.

The spores of the fungus are often scattered by watering or air currents. They are produced in great numbers on the spots of dead leaf tissue which fall out.

Control.—It is claimed that Bordeaux mixture can be used in the seed beds and on seedlings to keep the disease down, but if infestation becomes serious, thorough fumigation of the houses and soil sterilization will be profitable.

ONION DISEASES.

Mildew.

The only disease of importance affecting the onion that has come to our attention in Oregon is the mildew. This disease is one that has long been known as a serious disease in England and Europe and other parts of the world as well as in various sections of the United States. It is, without doubt, the most serious and destructive disease of the onion known. It has been reported from various sections of Western Oregon and has been particularly serious during the unusually moist season of 1912. It is found most commonly in Oregon on beaverdam soils.

Fig. 56. The result of mildew on the foliage.

Symptoms.—The disease attacks the leaves, causing them to collapse (Fig. 56). It usually appears first on a few plants in the field, but spreads rapidly in warm, damp weather. In the first stages of attacks the leaves of an infected plant will show a peculiar violet tint. If these leaves are examined closely this color is found to be due to the presence of a downy growth on the affected surfaces. In a day or two the leaves become weak and gradually collapse. The collapsed leaves dry up and may become covered with black mould, which the grower frequently mistakes for the cause of the trouble. It takes only three to five days from the first appearance of the trouble for the plants to be completely collapsed.

Cause.—The disease is caused by a fungus belonging to a group of disease-producing forms commonly referred to as the "downy mildews" on account of the appearance of the fungus on the surface of the diseased parts. It is known technically as *Peronospora schleideniana.* This fungus, like many others, has two spore stages. In the summer stage the spores are formed on branches of the fungus body which appear in great numbers on the surface of affected leaves. It is these spore-bearing structures which cause the downy appearance mentioned above. The spores are spread by the wind and cause new infections. Since the time required for the fungus to kill the leaves is very short, it is readily seen why the disease spreads so rapidly over a field once it becomes started.

The main part of the fungus body (mycelium) is within the leaf. This

consists of very much branched thread-like structures which send short branches into the cells of the onion leaves. These absorb the sap from the cells and hinder the proper discharge of their normal functions. The result is that the leaves gradually become weakened and die. The loss of foliage results in decreased size of bottoms and consequent reduction in yield.

On the mycelium within the tissues of the leaf, there are formed spores entirely different in character from those borne on the surface of the leaves. These spores may be referred to, for convenience, as resting spores. They serve to carry the fungus over the winter. They are abundant in the dead leaves or parts of leaves that lie on the ground over winter. In the spring, under favorable conditions, these spores grow and start the disease, which spreads rapidly in the field on account of the abundant production of summer spores on the surface of the leaves.

Treatment.—In those sections where onion mildew is troublesome, the foliage should be kept covered with a fungicide during the growing season to prevent the germination of the spores on the surface of the plant and the consequent infection. The best fungicide for this purpose is Bordeaux mixture. It should be used in the 5-5-50 strength and should be applied at intervals of from ten days to two weeks beginning when the plants show three leaves. Onion foliage is so smooth that Bordeaux prepared in the usual way does not adhere readily. It is necessary, therefore, to add some sticker to the mixture. This sticker is prepared as follows:

Mix together in an iron kettle 2 pounds of resin, 1 pound of Sal soda crystals, and 1 gallon of water. Boil in the open air until the mixture is a of clear brown color. This will require about one to two hours.

The above amount is sufficient for 50 gallons of spray.

POTATO DISEASES.

Late Blight of Potatoes.

The disease of potatoes commonly known as late blight or downy mildew is almost universal in extent and has caused more loss than all the other pests of this crop combined. In New York state it has caused a loss of $10,000,000 in one year and an estimate for the United States places an annual loss at $36,000,000.

The outbreak of blight in Ireland in 1845 is often spoken of as the starting point, but, as a matter of fact, records show that it originated in Chili, the home of the potato, and was introduced into the United States, near Boston, as early as 1840. In Australia and Tasmania the invasion has been more recent, probably in the present century.

In Oregon we have no record to show when the disease first appeared. It is certain that it has appeared occasionally in the coast region for years. The season of 1912 was unusually favorable to it and the fungus rapidly spread and damaged late potatoes throughout the Willamette Valley, the lower Columbia and Coast region. The large acreage planted made the loss in some cases quite serious.

Symptoms.—The leaves are the first point of attack when the disease is spreading in the field. Spots appear on any part, more often near the tip or margin, these affected areas spread rapidly until the entire leaf is blackened and dead. As the spot spreads, the margin is changed to a light green and is watery in appearance, often a fine white down can be seen, generally on the lower surface. Drought or unfavorable temperature will check the growth of the fungus, but if the mean daily temperature ranges between 70° and 74°, with an abundance of moisture, it will rapidly change the entire top into a moist, putrid mass and sweep over large fields in a few days (Fig. 57).

The damage resulting from the loss of the tops might not always prove serious, since the outbreak rarely comes until late in the season, but the fungus does not stop at this. The greatest loss may result from the attack on the tubers. Any exposed potatoes are pretty certain to become infected by the numerous spores formed in the spots on the leaves and if rains come many

Fig. 57. Late blight of potatoes. At this stage the tops appear very much as though frosted.

spores are washed into the soil and reach many potatoes below the surface. Rot follows and spreads in the hills. At digging time some of the infected potatoes are pretty certain to go into storage with the sound ones, and, if storage conditions are not properly watched, the entire lot may rot.

The tubers, when first affected, show slight depressed areas on the surface; these areas are dark colored and at first penetrate but a short distance beneath the surface (Fig. 58). This gradually advances into the interior until the whole tuber is decayed. If the soil is wet, the decay is aided by soft rot caused by bacteria, and where a field is affected in this way, the putrid odor of decay may be noticeable for some distance. The white tufts of the fungus on which spores are produced come out on the surface of the tubers when the soil or air is humid, in this way greatly aiding the spread of the disease.

Sometimes dry weather follows a period favorable to the spread of the blight. Under these conditions the fungus advances very slowly in the foliage, producing no spores and seldom spreading to new fields. The tubers which have been infected rot more slowly and take the form of a dry rot.

Cause.—At the time of the famine in Ireland in 1845 many ideas and theories were held concerning the cause of the potato blight. Some said it was a direct visitation of Providence, some ascribed the disease to insects, some thought it due to atmospheric influence or electricity, others said wet weather, and some were right in ascribing it to fungi. Many farmers still believe wet seasons to be the cause of this disease. The wet warm season does not cause the blight, but these conditions are essential to the growth and dissemination of the causal fungus.

The scientific name for this causal fungus is *Phytophthora infestans*. It has been the subject of a great deal of investigation, and much literature regarding it has been published from time to time. The group to which Phytophthora belongs shows a great deal of variation. Other more or less common forms which are closely related are the mildew of onions and the one frequently occurring on lettuce.

Fig. 58. Early stage of late blight on tubers.

The fungus grows, under natural conditions, in the following manner: Starting with a spore, the kind we find produced abundantly during summer, two things may happen. First, this spore may germinate by producing a germ tube. This will penetrate through the openings in the leaf surface, rapidly spreading and, after three or four days, cause the black, blighted areas to appear. Second, this spore may germinate by dividing into numerous smaller motile spores which are able to swim about in rain or dew on the foliage. These spores finally come to rest and germinate by means of a tube which penetrates the leaf and starts the blight. After the blighted spots have appeared, branches of the fungus grow out through the openings in the lower side of the leaf and produce more spores. When examined under a microscope, this downy white growth might be compared to a pine forest. Great numbers of trunks grow from the surface of the leaf or stem, branching several times and producing the egg-shaped spores at or near the ends, as the cones of the pine are produced. Some of these spores are scattered by wind and insects to other plants and the process is repeated. Other spores fall to the ground and are washed into the surface layer of soil where a few, upon germination, are able to reach the tubers and cause decay. On some tubers slightly depressed discolored areas (Fig. 58) are found, and if these potatoes go into good storage before decay has gone too far, the branching

threads of the fungus which penetrate all through the discolored portion will remain nearly dormant through the winter. When such a potato is used for seed, the fungus grows slowly into the shoot until late in the season. If favorable conditions prevail, it will then produce spores and rapidly spread to other plants and other fields.

It is thought that the fungus winters over in this way. Probably it is present in many tubers that do not show the discoloration.

It has been shown by several investigators that the fungus seldom if ever,

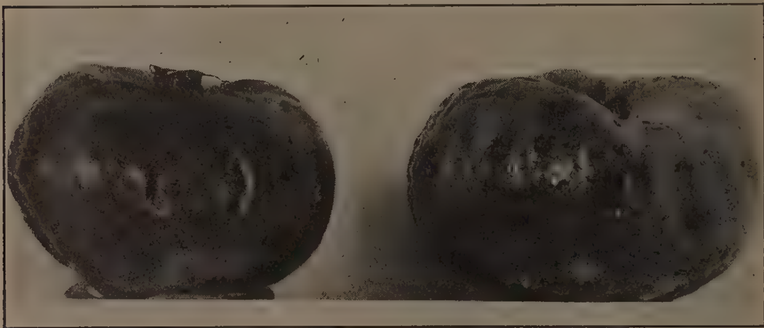

Fig. 59. Late blight of tomatoes. This disease is caused by the same fungus as the potato blight shown in Fig. 58.

runs back from the blighting foliage to the tubers through the stem, but that the spores carry it to the exposed tubers and those near the surface. This same fungus causes a blight of tomatoes (Fig. 59). It is favored somewhat on the tomato by the fact that the fruit is not only easily infected, but also furnishes a great abundance of moisture and food, so that great numbers of spores can be produced.

Treatment.—It has been very clearly demonstrated that late blight and the rot of tubers caused by the same fungus can be prevented by proper spraying. Several of the Eastern States have carried on spraying experiments for a number of years and in every case the results show a marked advantage. A spraying experiment to be worth anything must be carried on so that check (unsprayed) rows are kept in each field. A careful comparison must be made as to yield and yield of marketable potatoes between the sprayed and the unsprayed plots. Do not rely on a comparison made with a neighbor's yield, or with a different variety. The plots for comparison should be as nearly alike as possible.

No spraying experiments have been followed through in Oregon, and our inquiries indicate that growers are unfamiliar with the practice. It is recommended that spraying be given a fair trial and even during seasons when the blight does not appear, if spraying is practiced, follow it through and check up on the yield. It has been demonstrated that the vigor of the plant is held up in this way and an increased yield results.

The only satisfactory spray to use for late blight is Bordeaux mixture. Several applications during the season will be necessary and the time for spraying will depend on a number of factors; namely, time of planting, weather conditions, and other pests. If the spray is to be put on for blight alone it will be safe to put on the first application when the blossoms of the late plantings are well out, unless rainy weather sets in earlier, in which case spray as soon as possible after the rain. Follow this with later applications every two weeks. The first application should be with 4-4-50 Bordeaux mixture, and the later with 6-6-50. In the case of an epidemic of blight it is necessary to spray oftener, once every week or ten days being advisable.

Other pests, especially flea beetles, require an earlier application.

Dry Rot or Wilt.

This fungus disease is both a field and a storage trouble of wide distribution and often causes considerable loss. The trouble has long been known both in this country and in Europe, but little was known until recently concerning the exact cause. In the United States the "dry rot" has long been recognized as a serious trouble; just what the actual loss amounts to it would be impossible to determine. The damage in the field is even harder to estimate, for many times the grower is not aware of any disease or abnormal appearance.

In Oregon the disease is apparently wide spread. Investigations throughout the Willamette Valley and lower Columbia basin during the season of 1911 showed very few fields entirely free from the disease. The season of 1912 being exceptionally wet, this trouble seems not to have shown up as extensively.

Symptoms.—The wilt disease makes its attack on all parts of the plant below ground. It generally enters through a root and spreads to all other parts beneath the surface.

The first indication of the disease is a different appearance of the foliage. It gradually takes on a lighter color, loses its glistening appearance, and the

Fig. 60. Wilt of potato vine caused by the soil fungus, Fusarium. Dry stem-end rot of tubers is caused by the same organism.

leaves roll in during the heat of the day. (Fig. 60.) If the plant is attacked while growth is still taking place, it is quite certain to be dwarfed. The death of the plant comes on slowly and to the casual observer would seem to be little different from the normal maturing. It is premature, however, and the yield is much cut down. It has been shown that the growth in weight of potatoes, and accordingly the yield, continues to increase at a remarkable rate for every week added to the normal growth of the top. Premature ripening from any cause certainly results in reduction of yield.

As the plant slowly succumbs, owing to the death of the roots, it falls over and can be more easily detected. Such plants pull easily. The roots are easily broken and are often covered with a white or pinkish fungous growth. The main root is discolored; frequently this brown discoloration can be followed along the underground stems into the stem end of the tubers. In this way, the fungus enters the potatoes and, under favorable conditions, it produces the dry stem-end rot. If rot is not produced the fungus can live over

winter in the tubers and so spread with the seed potatoes to new fields. Such infected tubers can be detected if a thin slice is cut off at the stem end. If the fungus is present the vascular or fibrous tissue is brown and this tissue spreads so that a ring or a portion of a ring of the brown spots appears on the cross section at different depths, always following near the surface of the potato. This brown discoloration may follow the fibers back only a very short distance or it may extend very nearly to the apical end of the tuber; in either case it indicates the presence of the disease. In case of rot the fungus does not confine its attack to the vascular tissue but slowly spreads from it through the surrounding tissue, finally breaking it down. As it comes to the surface it breaks through and produces dense tufts of the delicate white fungus.

Cause.—The cause of this disease is a soil fungus *(Fusarium oxysporum)*. It is closely related to the organisms causing the western tomato blight and the wilt of watermelons. It can live for years as a saprophyte, depending on dead organic matter in the soil for food. When potatoes are planted on infested soil the fungus again assumes its parasitic habit and produces disease of the living plant.

Like the fungus causing watermelon wilt, this fungus forms small spores which are produced in the vessels of the plant, and larger curved spores on the surface. These larger spores will withstand long periods of drought or cold and germinate when conditions are favorable. They are scattered by wind and insects or at digging time by the implements used in the field.

Control.—The fact that this fungus is a persistent soil organism, capable of producing disease whenever potatoes are planted in soil where it is present, makes it necessary to use precaution in keeping the fields free from it.

All seed used should be carefully inspected. It would be a simple matter if, at the time potatoes are cut for seed, a thin slice be cut at the stem end and any tubers that show brown discolorations of the fibers be discarded. In case infected seed is found it will be advisable to use in addition, the formalin seed treatment as for potato scab. This will dispose of spores which may have collected on the surface. It will not, however, serve to disinfect potatoes which show the brown discoloration of the vascular tissue.

Decaying potatoes often carry this fungus to the compost heap, either directly or through being fed to stock. Such practices are to be avoided. Also avoid cultivation or travel from diseased fields onto new land or land where the disease does not exist.

Where the fungus is once established in a field, practice long periods of rotation preferably to cereal crops. An attempt is being made at the Station to develop a potato that will be resistant to this disease. There is evidently a varietal difference in this respect, and in time a strain may be developed through processes of selection and breeding which will prove highly resistant.

Rhizoctonia, Little Potato.

This disease is widely distributed in this country and in Europe and Asia. The fungus causing it attacks many other plants and consequently is an organism having a wide range of destruction. It is often present when very little damage is caused, however, and seems able to live indefinitely in the soil.

During the season of 1912 this disease has been found on potatoes in Oregon in the Coast region and lower Columbia River Valley and has caused a loss of 30% in some cases.

Symptoms.—The affected plant displays a number of symptoms, some of which accompany the disease only under certain conditions. We often find aerial potatoes (Fig. 61), potatoes produced on parts of the stem above ground, resulting from early attacks of the fungus. This does not always follow, however. Sometimes this production of aerial potatoes is brought about in other ways. It has been observed in a field where gophers had worked around the roots and cut the underground stems of the plants. Many times the tops are large, or an abnormal branching, resulting in a rosette, accompanies the attack on the underground parts; in this case many small potatoes are produced close to the surface of the ground. Sometimes as many as fifty potatoes, varying

Fig. 61. Aerial potatoes caused by Rhizoctonia. Plants are infected from the soil.

Fig. 62. Rhizoctonia on the stem of a young, rapidly growing potato plant.

from the size of a pea to that of a hen's egg have been found in such hills.

When conditions are favorable for the fungus to attack the plant early in its growth, death may follow immediately. In such cases the stem rots off at the surface of the ground and the plant falls over. Fig. 62 shows the grayish white fungous growth on the stem just above the surface of the ground. The stem has not rotted off, yet the plant was too young and succulent to withstand the attack for any length of time.

Rhizoctonia, as it occurs in this country, probably does not directly damage the tissue of the tubers but it frequently forms small, irregular growths on the surface which give them a scabby or dirty appearance. These fungous growths are so firmly attached that a vigorous scrubbing is necessary to break them away. When wet they are black in color. (Fig. 63.)

Cause.—*Corticum vagum* var. *solani*.—The fungus causing this disease is closely related to the mushrooms and toadstools. It was, for many years, considered a sterile fungus and supposed to have no true spore stage. This has been disproved and the classification changed, since it has been found that spores are produced.

The fungus can live indefinitely without the intervention of the spore stage and it is probable that it depends largely for its distribution and perpetuation on the small patches of fungous tissue (sclerotia) that are formed on the surface of the potatoes and stems. (Fig. 63.)

Fig. 63. The small black patches on the surface of the tuber are a resting condition of Rhizoctonia and furnish a means for its distribution.

Control.—Since this fungus is able to live in the soil indefinitely, it is necessary to observe special precautions against introducing it. It is introduced, in most cases, on seed. Careful inspection for the presence of the small black bodies on the surface of the potatoes should always be made before planting and, in case they are found, the general seed treatment as recommended for potato scab should be used.

Liming the soil and rotation with crops which are not affected is also recommended where the disease is prevalent.

Black-leg.

Blackleg or black stalk rot, as it is frequently called, is a bacterial disease of the potato which has only recently become widely distributed in this country. It is quite probable that the disease was present in certain potato-raising localities before 1906, but that date seems to furnish the first record of its occurence.

The disease has been known in Europe for a longer period and was recorded in Canada in 1900.

Symptoms.—An examination of plants affected with blackleg will leave little chance for confusing this disease with other described potato maladies. The stem and tubers are the parts attacked. The inky black discoloration of the stem at the surface of the ground, from which the name originated, is the most constant character associated with the disease. This blackened area starts at the point where the stem leaves the seed potato; it extends up to the surface of the soil and in some cases may follow the stem several inches higher. The illustration (Fig. 64) shows the result of an artificial inoculation in which the organism followed the stem up to the third leaf.

One who is familiar with this disease can detect its appearance before the blackened area appears on the stem. The whole plant is slightly below normal size, lighter in color, with stems, petioles and leaf blades erect. This condition becomes more acute until finally the plant rots off and dies. The seed tuber is generally affected and in most cases decay starts in it before the plant shows signs of disease.

Cause.—The term black-leg is to be considered in a general sense and includes a group of bacterial organisms, all of which have been found capable of producing the disease described under this name. *Bacillus phytophthorus* and *Bacillus solanisaprus*, are two that have been studied perhaps more than any others.

These organisms are capable of causing soft rot when they come in contact with bruised or cut surfaces of the tubers. It is probable that such conditions are essential in order that the bacteria may live over winter. They cannot withstand drying, and in the East it is thought that winter conditions are too severe for them to live over in the soil. It has also been shown that decaying, bruised or cracked tubers will carry the disease over and produce affected plants.

The disease appears early in the season. When plants have lived long enough to form a hard woody stem, this trouble seldom affects them; this may, however, be due to the fact that the organism becomes immediately active and so kills off the plants wherever it has obtained an early foothold. Since it does not spread from hill to hill in the field, no serious epidemic has been known. Wherever loss is caused, only occasional scattering plants are taken; in some cases this amounts to rather a high percentage, however, and should not be overlooked.

Control.—Since this bacterial disease does not, to our knowledge, live over in the soil, it must be introduced on the seed. It is not a difficult matter to inspect the seed and discard any that are decaying, bruised or discolored, and this practice should be followed. In addition, use the seed treatment with formalin, as given under potato scab and you should be able to eliminate this disease.

General Consideration.—This disease has not been studied to any extent in the Pacific Northwest, consequently we cannot be certain that the bacteria causing it will not winter over in the soil under our conditions. In fact, our

Fig. 64. The plant at the center was inoculated with the black-leg bacterial organism. The plant to the right was a check and was not inoculated.

conditions are such that we may find it living for some time and causing more serious trouble here than it has in the East. The Station is desirous of observations on this point and any information will be greatly appreciated.

Potato Scab.

Potato Scab is a fungous disease that is prevalent in Europe and the United States and probably in all countries where potatoes are raised. The chief

loss is in the depreciation in value due to the appearance of affected potatoes, although it is claimed that the yield is also reduced.

In Oregon, scab is prevalent only in fields that have been heavily manured, where wood ashes have been applied, or in alkaline soils. An abundance of moisture also favors its spread and development.

Symptoms.—This disease is confined to the tubers and is readily recognized by the characteristic rough corky patches on the surface (Fig. 65). The affected spots may be quite deep, even forming cracks if the attack is made when the potatoes are small. The lenticels or openings in the surface

Fig. 65. Tubers affected with scab.

are the points more often affected. The first indication is a small reddish brown surface spot; this grows both outward and downward and soon a brown corky growth begins to form over the diseased area. These spots are rarely more than one-half of an inch in diameter, although many such spots may grow together forming large scabby areas over the surface.

Cause.—*Oospora scabies.*—The fungus causing this disease is a very minute form. Spores are formed that are but little larger than some of the bacteria. It is a parasite, but is able to live in the soil in old stems or decaying vegetation for several years. Turnips, beets and mangels are sometimes affected.

Control.—Avoid planting on alkaline or heavily manured soils. Where the soil already contains the fungus, practice rotation with crops not affected and where possible plow under green crops.

Avoid planting scabby seed on land that is clean. If it is necessary to use potatoes that are scabby, the following seed treatment should be given:

1. Use a solution of one pint or pound of formalin in 30 gallons of water, soak the potatoes in this for two hours, then spread them out to dry before cutting. The sacks or crates should also be treated at the same time.

2. When a large quantity of seed is to be treated the gas method will be more simple. This method consists in producing formalin gas by adding commercial formalin to potassium permanganate crystals. An air-tight shed should be provided large enough to hold whatever quantity it is desired to treat and providing for an open space near the center which should be about six feet across. The potatoes to be treated should be dry. They may be kept in sacks or crates and should be stacked in such a way that air spaces are kept open around them. For the gas generator use a large pan or tub, place this in the center of the open space and spread the crystals of permanganate over the bottom. When all is ready add the formalin and leave quickly to avoid the suffocating fumes. Use these substances in the proportion of 23 ounces potassium permanganate with three pints of formaldehyde to every 1000 cubic feet. Keep the shed closed as tightly as possible for 24 hours. At the end of this time it may be opened and the potatoes taken out.

Since the gas is more effective in a humid atmosphere, it is a good plan to sprinkle the floor with water before starting the sterilization.

TOMATO DISEASES.

Western Tomato Blight.

This disease of tomatoes has, for some time, caused severe losses to growers and in certain sections has forced them to give up what would otherwise be a very profitable crop. It is apparently confined in distribution to the region of the Northwest known locally as the "Inland Empire." In Oregon it is serious only in the eastern sections of the state and westward along the Columbia River.

This disease is characterized by a gradual yellowing and curling of the foliage; as the leaf tissue turns yellow the veins take on a purplish color. The plants are dwarfed and fail to mature fruit. The stem of an affected plant is thickly covered with glandular hairs, the stain which they produce seeming to be much more abundant than from a healthy plant. The root systems of diseased plants are often very different from the normal healthy ones. The smaller lateral roots show the effect of some organism. They are at first discolored and finally die back. Where such a root is killed, several more start at its base from the main root to replace it. These are often killed and the same thing happens again, so that a cluster or mat of short laterals is produced instead of the long normal feeding roots. This condition has led to an investigation for the presence of a fungus which attacks the roots from the soil.

Investigations have been carried on for some time at the Washington State Experiment Station, where Professor H. B. Humphrey has succeeded in proving that the causal fungus is a species of a common soil organism. This fungus is a difficult one to combat. There are several further experiments to be tried toward this end. So far the following courses are recommended:

Treatment.—The work at the Pullman station seems to show that the most help along control lines at present can be obtained if the seed bed is done away with. The seed should be planted four to a hill and in hills three or four feet apart in the field. Individual forcing boxes should be used, if practical, until the plants are five or six inches high. After removing these, thin the plants so as to have one to a hill.

The experiments where this method was tried showed a very small percentage of blight as against varying losses where checks were kept by setting plants from seed beds. The difference probably is due to the fact that the roots are injured in transplanting, thus furnishing the fungus an opportunity to enter.

Another course which may well be pursued is the development of a resistant strain. The grower first selects several desirable varieties. These are planted where it is known that the disease has appeared previously and from any plants that mature fruit, seed is saved. Mark especially any plants that show resistance to the wilt and take the seed from several tomatoes on such plants. The following season this method is followed out again, using the seed saved from the seemingly resistant plants. After several years of careful selecting, a strain should be obtained which will retain the character of resistance.

Wilt or Summer Blight.

This disease is very much like the western tomato blight in many respects, but should not be confused with it. It is described as occurring throughout California, and, in some instances, causing a total loss of the plants in a field.

In Oregon occasional reports, of what is quite certainly this disease, have come from the southern part of the state.

Symptoms.—The trouble makes its appearance in the early summer. Often the plants are quite large and fruit is set before the disease begins to appear. Scattering plants through the field are the first to appear sickly; these gradually fall behind the rest in growth, take on an unhealthy color and finally wilt. The wilting is at first noticeable during the hot part of the day only, but as the disease progresses, the plant finally collapses entirely. This condition may continue to spread through the summer until very few or no plants are left.

Cause.—The cause of this disease is a species of Fusarium, a common soil fungus. This fungus attacks the roots from below the surface of the soil and causes a root rot. It also enters the conductive tissues of the plant, where it spreads and plugs the vessels so that the water supply is prevented from reaching the top, and as a result the plant wilts.

Treatment.—As regards control measures little of value can be recommended. In some cases it may be advisable to sterilize the soil in the seed beds in regions where the trouble is prevalent. This method would not generally prove practical, however, and the use of new land, when possible, is to be preferred.

There is more hope in combating this disease by the development of resistant strains or races. While this is a slow process, it has proven satisfactory where similar diseases have occurred in other plants. (See western tomato blight for method to employ.)

Downy Mildew, Blight.

This disease is due to the same cause *(Phytophthora infestans)* as the late blight of potato. It has been quite prevalent in Oregon wherever the potato blight occurred during the season of 1912 and it has caused the loss of a large percentage of the crop in that section. (For full account see late blight of potato.)

Leaf Mold.

This fungus disease *(Cladosporium fulvum)* is often found on tomatoes when raised under glass. In the South it is sometimes destructive in the open. In Oregon, where greenhouse men are familiar with it, little concern is felt, for while the foliage is somewhat decreased in efficiency, it attacks only the older leaves and the plants mature a good crop. The yield is probably held down, however, and careful comparative tests will doubtless show the advisability of spraying.

Symptoms.—This fungus attacks the older leaves, causing yellow spots to appear on the upper surface. On the lower side these spots are darker in color, and on close examination will be found to be covered with a gray-colored mold or fungus. Many spores capable of spreading the fungus are produced on this growth. Air currents, water or insects furnish means of scattering to other leaves.

Control.—The most satisfactory method of control is the maintenance of dry atmosphere. The foliage should be sprinkled only on very bright dry days. It is claimed that sprinkling lime-sulphur on the heating pipes has checked the fungus.

Blossom-end Rot—Point Rot.

This disease is quite generally distributed throughout the country. It seldom causes extensive loss, but from the fact that it is more serious on the early crop, the financial loss becomes a factor of importance.

This rot may occur at various stages of development of the fruit, generally before it has reached full size, and, as has been stated, early in the season. It makes its appearance at the blossom end in the form of sunken brown spots which gradually enlarge. Such spots are dry and hard. Many times molds or bacteria gain entrance at this point when the fruit is imperfect and cause decay. Such troubles should not be confused with the one under consideration although they frequently follow it.

The true cause of point rot does not seem to be thoroughly understood. There is evidence to indicate that it is an infective disease, the cause of which is distributed by insects.

It is known that the trouble is more serious in dry weather on light soils where the supply of water is insufficient. This can be corrected either by irrigation or by adding organic matter so that the water-holding power is increased. Surface tillage should also be practiced. Experimental work has shown that sub-irrigation is better than surface watering and that where plants are shaded so that transpiration is reduced the amount of rot is considerably lessened.

WATERMELON DISEASES.

Wilt.

The fungous wilt of watermelons is a disease that causes great loss in certain sections of the country. Once established in a field, it will live there for years and kill off the plants whenever watermelons are planted in it.

The disease is quite generally distributed throughout the southeastern part of the United States and has been reported from Iowa, Indiana, Arizona, Oklahoma and California. It is also destructive in some parts of Oregon.

No record is known of this disease occurring in Europe.

Symptoms.—The name indicates the characteristic symptom, the wilting and drooping of the foliage as though the water supply were cut off (Fig. 66). This wilting comes on suddenly and in a very short time the plant is dead. If the main stem of a wilted plant be cut in cross section, the woody part is found to be yellow and discolored, making a marked contrast with the normal plant in which the tissues are uniformally white. Sometimes a pinkish, mold-

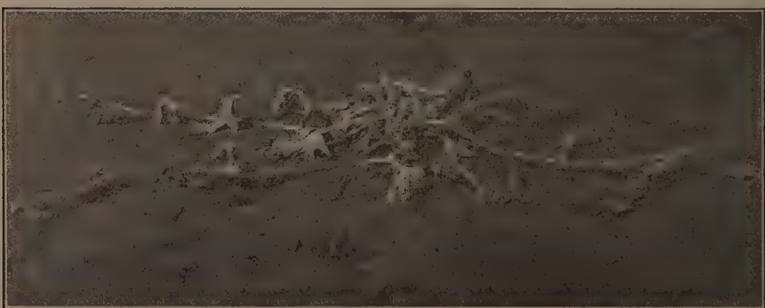

Fig. 66. Watermelon wilt, a serious disease in some sections. This disease is caused by a soil fungus.

like growth comes out on the surface of the stem soon after the plant is killed, extending for a foot or more up the stem from the crown.

Cause.—This wilt is caused by a Fusarium, a fungus which is capable of living in the soil for several years and may attack any melon plants that are afterwards planted in fields where it exists. This fungus is composed of a very delicate branching thread-like growth, so delicate, indeed, that its presence could not be detected in the soil. This growth, on coming in contact with the tender roots of the melon plant, is able to penetrate them and, once within the tissues of the plant, it finds the proper nourishment for rapid growth. Very small spores are produced and set free in the vessels, where they germinate to start new points of infection. These spores, having germinated, produce a growth which plugs up the vessels and so prevents sap flow. This condition results in wilt and in the death of the plant. The fungus rapidly spreads through the roots and older part of the vine, often coming to the surface where another and larger kind of spore than those formed within the vessels may be produced in great numbers. These spores are readily carried by wind or insects, thus helping to scatter the disease over wide areas.

Another way in which this disease is frequently spread to new fields is through the application of manure. Diseased plants frequently are carried to the compost heap. It is also claimed that the fungus spores are not killed when passing through the alimentary canal of cattle. It is, therefore, necessary to avoid any chance for cattle to pasture on wilted vines.

Treatment.—Take every precaution, in the first place, to keep the disease from spreading to new fields. Tools used in a field where the disease is found should be cleaned and sterilized before using them in ground free from the trouble. Do not drive or walk directly from the one to the other or allow soil to be transferred, as might be the case where irrigation is practiced. Keep the compost heap free from the fungus. If doubtful on this point, it would be advisable to try fertilizing a few isolated plants for a year before taking a chance of infecting new fields.

When the disease appears in a patch the plants affected should be removed and burned as soon as they are discovered.

In districts where this wilt is already widespread and the further culture of melons is desirable, the only course open to the grower is to secure a resistant strain by breeding and selecting. This has already been done in several localities in the Southeast and work is in progress toward this end at one place in the Willamette Valley. It has been found that these resistant strains can rarely be transferred to new localities and still retain their resistance. The problem, therefore, becomes an individual one for each section of the country. The task will take several years and it will be necessary to devote several acres of good melon soil to the work in order to secure the desired results.

The experimental work consists in crossing the watermelon with the citron, which is more hardy and resistant to the wilt. By following the breeding with careful selection, a resistant melon having good flavor and shipping qualities can be developed.

The details of the work necessary can be obtained on application to the Department of Plant Pathology.

FIELD CROP DISEASES.

By H. S. JACKSON.

SMUTS OF GRAIN CROPS.

Undoubtedly the most common and serious diseases affecting the grain crops, wheat, oats and barley in Oregon, are those commonly referred to as the "smuts." These diseases are, no doubt, familiar to most farmers, since they are common in all sections of the state wherever cereal grains are grown.

The same diseases affect these crops in all sections of the United States and of the world. The loss due to smut in any field is not difficult to estimate, since a diseased plant does not produce seed. The yield is therefore reduced by the same percentage as the diseased plants in the field. This varies greatly, up to 10, or in exceptional cases 20 or more, per cent. The loss due to oat smut alone, taking into consideration the entire country, has been estimated by good authorities as about 8%. The covered or stinking smut of wheat in exceptionally severe cases has been-known to cause a loss of two-thirds of the crop. Beattie estimated the loss due to wheat smut in the state of Washington in 1902, after a severe infection, at one-fifth of the crop, or a financial loss to the farmers of the state of $2,000,000.

No attempt has been made to collect data as a basis for determining the average percentage of smut in the grain fields of Oregon. No doubt the relative loss is much less than it was several years ago, since seed treatment is now quite generally practiced by farmers in many localities.

From observations made in the state during the past three years, it is evident that there is still a very considerable percentage of loss. Based upon the above statements of estimates of losses in other sections or in the country at large, and from observation and correspondence of the writer, it is believed that an estimate of from two to five per cent annual loss from all grain smuts in Oregon would be conservative.

The 1911 Year book of the U. S. Department of Agriculture gives the yield of wheat, barley and oats in Oregon in 1911 as follows:

Wheat,	16,726,000 bushels, having a farm valuation of	$12,545,000.00
Barley,	3,944,000 " " " "	2,564,000.00
Oats,	12,457,000 " " " "	5,481,000.00

If we take these figures as a basis, the annual loss from smut in Oregon is certainly from $500,000 to $1,000,000 annually. If we should accept the estimate of 8% loss due to oat smut throughout the country, then Oregon's loss in 1911, due to oat smut alone, would be $438,480.

Practically all of this loss is easily preventable at small cost to the grower.

Cause of Smut.

The smut diseases are caused by minute parasitic fungi which enter the plant in the young embryo or seedling and grow in the tissues of the developing plant until the grain heads out, when the affected plants are found to produce heads or grains which have been reduced more or less completely to a black powdery mass. The fungus as it grows in the seedling is invisible, hence affected plants cannot be detected with certainty till they head out. The powdery mass to which the tissues of the head or grain are reduced is made up largely of the reproductive bodies or spores of the fungus causing the disease.

The various grains are attacked by different species of smut which affect the plant in slightly different ways. The smut of oats, as described below, reduces the entire seed and a large part of the chaff to a smutty mass. The covered smut of wheat affects only the interior of the kernels. The loose smut of wheat reduces all of the head, except the stalk, to a smutty mass. The smuts of any one crop will not cause disease in any other. The clean seed of wheat could be mixed with oat seed containing smut and no smut would result upon wheat. There are two distinct species of smut-producing fungi affecting each of the three grain crops under consideration.

While there are certain general resemblances in the life history of all grain smuts, there are certain other important differences which make necessary an entirely different course of treatment.

All of the smuts of wheat, barley and oats are disseminated through the seed. The different forms, however, fall naturally into two distinct groups, which are most easily determined by the relative maturity of the smutted heads and the natural maturity of the host plant. In one group the spores are mature and disseminated when the seed is mature or approaching maturity; that is, about the harvest time of the host plant. In the second group the spores are disseminated during the blossoming period of the host plant.

The oat smuts, the covered or stinking smuts of wheat, and the covered smut of barley, belong to the first group and the causal fungus in each case matures about the harvest time of the host plant. The dusty mass of spores is disseminated by the wind, or during the process of threshing the grain, and the spores may thus come to rest upon the surface of the normal seed. These spores remain alive till planting time and are planted with the seed grain. When the seed germinates the spores also germinate and entering the tissues of the young seedling soon after it breaks from the seed coats, lives and grows inside the grain plant till it heads out, when all so infected are found to have diseased heads.

Since the spores which cause the infection are on the surface of the seed grain when planted. any method of soaking the seed in a fungicidal substance which will kill the spores of the fungus without injuring the germination of the seed will prevent the disease.

The loose smut of wheat and the loose smut of barley belong to the second group and will be found to mature earlier. The smutty masses are formed and the spores disseminated about the time the wheat or barley is in blossom. These spores are blown about by the wind, sift down between the chaff of the blossoms, and coming to rest upon the developing seed, grow into the tissues of the young developing embryo, so that when the seed is mature there is present within the tissues threads of the fungus causing smut. It is impossible to detect such seed. They are perfectly normal in every way except for the presence of the fungus in the tissues. When planted they germinate normally and appear to grow as other wheat or barley plants, but the fungus is, in the meantime, growing in the tissue and when the plant would normally come into blossom the entire head is found to be reduced to the characteristic smutty mass. Since the fungus is in the tissues, no method of soaking the seed in fungicidal substances is of any value in preventing this type of smut. Special preventive methods described below are necessary.

Loose Smut of Oats.

Oat smut can best be observed at the fruiting time of the fungus when affected plants are seen to have the infloresence more or less destroyed and reduced to a black powdery mass which is easily scattered by the wind. Usually all the heads of a plant are smutted. The chaff as well as the kernel is affected.

Cause.—Oat smut may be caused by one of two fungi known as *Ustilago avenae* (Fig. 67-A) or *Ustilago leavis* (Fig. 67-B). These are usually found together in the field, though it is probable that in Oregon the *Ustilago leavis* is most abundant. For practical purposes they may be considered as the same species, though the latter has smooth, while the former has slightly echinulate, spores. The latter does not so completely destroy the infloresence. It should be particularly noted that the fungus causing oat smut does not reach its full maturity till after the plant is in blossom and is approaching maturity. Usually the heads are found to be disseminating the spores most abundantly just before harvest time. The dust-like spores are scattered by the wind and become attached to the chaff surrounding the seed. These spores remain alive on the surface of the seed through the following winter and in the spring are planted with it. When the seed germinates the spores of the fungus also germinate by producing a short mycelial thread, on which are formed numerous secondary spores or sporidia. These germinate in turn, and the germ tube penetrates the tender tissues of the young oat plant. The mycelium grows in the tissues with the developing plant, apparently doing it little injury, and is not observed until the maturity of the oat plant, when it is seen that the entire floral parts have been more or less changed to a black powdery mass of spores.

Treatment.—Oat smut is easily prevented by seed treatment. The spores of the fungus cling to the enveloping glumes and seed coats, and any method of killing the spores without affecting the germination of the seed will render this seed free from smut. Several methods of treating such oats

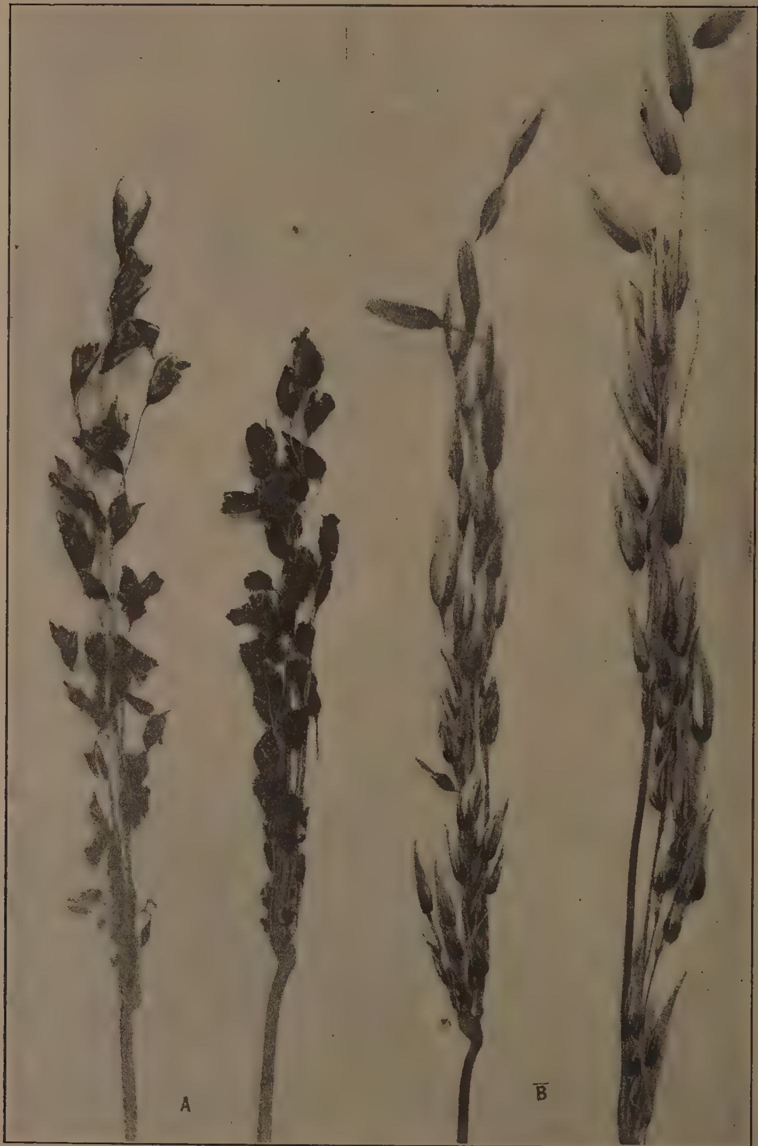

Fig. 67. Oats affected with loose smut. A. Appearance caused by *Ustilago avenae*.
B. Appearance caused by *Ustilago leavis*.

for the prevention of smut have been developed, any of which, if properly applied, are entirely efficient. The method most universally used and the one which is most generally recommended is the formalin treatment. Special methods, known as the hot water treatment, Sar treatment, have given good results. Information regarding any of these methods will be cheerfully given by the Department of Plant Pathology on application.

Below is given in detail the formalin method only:

Soaking in Formalin Solution.—This solution is prepared by mixing thoroughly one pint of guaranteed formalin (40% solution of formaldehyde in water) in 45 gallons of water. A barrel is convenient for this purpose. Put the grain to be treated in coarse sacks, with only about one-half bushel of seed to the sack. Plunge the sack containing the seed in the solution for a moment, allow to drain and repeat this process with agitation till it is certain that all the grain has been thoroughly wet with the solution, then the sacks may be set aside for 12 hours to drain. Afterwards the grain should be spread out upon a clean barn floor or canvas in a thin layer and allowed to dry. The floor must be clean. This is best accomplished by previously sprinkling with formalin solution. The grain may be dumped into piles immediately after dipping on a clean floor or canvas and covered with sacking, where it is allowed to remain over night or from 12 to 24 hours, after which it should be dried. It is found that about 40 gallons will treat about 50 bushels of grain. If desired, the seed may be soaked for one hour, though it should not be soaked longer than this. If the treatment is made just previous to sowing and the grain is slightly swollen from the treatment, then the drill should be set accordingly.

Certain precautions are necessary in order that this treatment may be successful. The formalin must be of full strength. This is important since if it is too weak the treatment will not be effective. The grain must be dried quickly after treatment, and under no conditions should it be allowed to sprout. Care should be taken that the grain should not freeze when wet. The grain may be treated several months before planting, but if this is done great care must be taken with the grain after treatment to prevent its becoming contaminated again. Hence it should be stored in sacks that have previously been boiled or soaked in formalin or placed in tight bins that have been previously sterilized by being washed in formalin solution or corrosive sublimate (1 to 1,000).

Sprinkling With Formalin.—If large quantities of grain are to be treated, the sprinkling method may be found more convenient, though experience has shown that the dipping method is more uniformly successful in the hands of the farmer. The solution used is the same. Place the grain on a clean floor or shallow box or canvas. The grain should not be spread more than six or seven inches in thickness. Apply the solution with a sprinkling pot or by any other convenient method. Sprinkle the grain and then shovel over. Alternately sprinkle and shovel the grain thoroughly until it is uniformly moist. The grain should then be piled, covered over with sacking or blankets and left over night, after which it should be thoroughly dried as described above. One gallon of the formalin solution is sufficient for about one and one-third bushels of grain.

Do not, under any conditions use bluestone treatment for oat smut, as it has been found to injure the germination.

Stinking or Covered Smut of Wheat.

The stinking or covered smut of wheat, also known commonly as "bunt," is quite different in appearance from the oat smut, though the essential features of the life history are very similar. The part of the head reduced to a smutty mass is the kernel (See Fig. 68). Usually every kernel in the head and every head in the plant is found to be affected. The affected heads are usually not observed until nearly ripe. The smut balls are surrounded by a definite wall, which is the modified wall of the wheat grain. These are at first unbroken, but later may be cracked open, exposing a smutty mass. In affected heads the chaff is found to spread more than in normal heads so that the kernels are

Fig. 68. Heads of wheat infected with covered smut.

exposed. The affected heads are lighter than normal ones and consequently stand erect. The smutty heads give off an odor like that of decayed fish. The smut spores are disseminated to some extent by the wind in the field and the healthy kernels may thus become covered with the spores. It is probably spread most abundantly, however, during threshing. It has been found that clean seed may become contaminated by the use of a threshing machine that had previously been used to thresh grain in which there was considerable smut.

The loss due to the covered smut of wheat, especially where abundant, is greater than the direct reduction in the crop due to the percentage of heads affected by smut. As above stated, the covered smut has a decidedly unpleasant odor and even when present only in small amounts this may result in a reduction in price. Where the smut is particularly abundant special methods of cleaning must be resorted to which add to the expense of the farmer.

Treatment.—Since the life history of covered smut of wheat is essentially like that of the oat smut, the same method of treatment will prevent the disease.

The formalin treatment has been found to be generally effective. It is advisable, however, to place the seed grain, before dipping or soaking in formalin, in a barrel or vat of water and thoroughly agitate it. The smut balls will then rise to the surface and can be skimmed off and destroyed.

Blue Stone Treatment.—In addition to the methods of treatment described under oat smut, the so-called blue-stone method may be used and usually gives good satisfaction. If desired, a strong solution may be made by dissolving one pound of blue-stone in four gallons of water and the seed grain dipped and dried as described under the formalin method. The grain should not be allowed to soak in this strength. Another method is to prepare a weaker soltuion by dissolving blue-stone in the proportion of one-pound to 25 gallons of water, and allow the seed grain to soak in this for 12 hours with occasional stirring. The grain, after soaking, should be dipped in lime water for 10 minutes. The lime water is prepared by slacking one pound of stone lime in 10 gallons of water. After treatment the grain should be dried.

In some sections the covered smut of wheat is found to be quite serious, even where the wheat is carefully treated, and, on this account, it is suspected that the smut fungus may remain alive in the soil over winter. If this is true, even though the fungus spores are killed on the seed, the seed might be planted so as to lie close enough to live spores in the soil to become infected. It is probable that this does not occur where rotation is practiced. Wherever the evidence indicates that this condition occurs, growers are advised to use the blue-stone treatment, since, if this treatment is properly carried out, by finally dipping in lime water, there is left upon the seed coats a slight deposit of

copper compounds which retain their property of killing fungus spores for a considerable period.

Other methods are in use, notably the hot water method, which is cheap but requires careful application. Those who wish the details of this method may obtain them by applying to the Department of Plant Pathology.

Loose Smut of Wheat.

The loose smut is very different from the stinking smut of wheat, both in appearance and in the life history of the causal organism. As shown in the left hand specimen in Fig. 69, it forms dusty olive brown spore masses in the spikelets of the wheat. This occurs at the flowering time of the host plant and the floral parts are usually entirely destroyed. The dusty spore masses are blown away or are washed off by the rains, leaving only the naked stalk or rachis, as shown in the right hand specimen of Fig. 69. Frequently the grower, when questioned about this disease at harvest time, will say, "Yes, it was very bad earlier in the summer, but lately we didn't notice it." Had he examined his field closely at harvest time, he would have found many naked stalks from which the smutted masses had been disseminated.

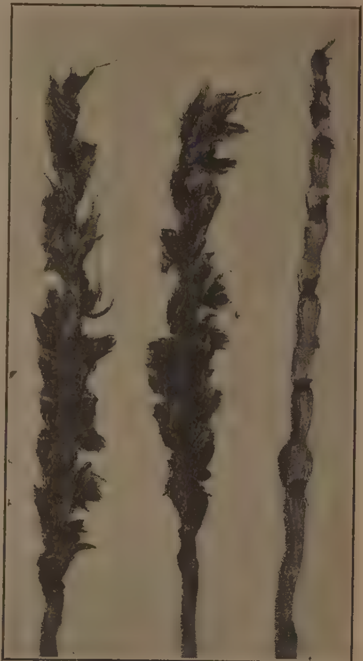

Fig. 69. Loose smut of wheat. Specimen at right shows condition at harvest time.

The essential points to be noted in the life history are as follows: The spores of the fungus are mature at the normal blossoming period of the host, are disseminated by the wind and carried to the flowers of the uninfected heads. Here they germinate and the mycelium enters the tissues of the developing seeds, finding its way to the growing part of the embryo wheat plant. The fungus remains dormant inside the tissue of the seed till it is planted and germinates, when the fungus grows with it, following closely the growing point of the wheat plant, doing no apparent injury till the time the blossom spike appears, when it is found to be almost converted into a mass of smut spores, which, in time, are disseminated and infect other plants.

Treatment.—In connection with the treatment of the disease it is important to note that the fungus exists in the tissues of the seed and on this account seed treatment by soaking in fungicidal substances as for oat smut and covered smut of wheat, is of absolutely no value, since fungicidal substances act only when the spores are on the surface.

It has been found that there is a difference in the degree of temperature which the embryo of the wheat plant and the fungus are able to stand without injury. This fact has been utilized in the development of a method of seed treatment known as the Jensen modified hot water method. This method requires very careful application and on this account is not applicable to the treatment of seed for a large acreage, though when carefully applied it is found to be entirely successful. Freeman, formerly of the U. S. Department of Agriculture, recommends the use of this hot water treatment in connection with a seed plot. The plan is to treat a relatively small quantity of seed by

the hot water method and plant in a seed plot and with the grain obtained from this plot, sow the main crop the following year. If the smut can be entirely prevented by seed treatment in this seed plot, and if this plot is grown in such a situation that it will not be contaminated by smut blown from another field, it will be clean and the seed obtained in this plot will not require further treatment the following year, since the infection can only occur at blossoming time. This seed may then be used to plant the main crop the following year.

Location of Seed Plot.—It is important that the location of the seed plot be carefully selected. Plots should be of sufficient size to provide enough grain for seeding the main crop the following year after allowing for loss in cleaning, etc. The seed plot should not be located in the vicinity of any field of wheat in which loose smut might be present, since it is found that spores may be carried by the wind for considerable distances. This isolation can be accomplished by growing some other crop than wheat immediately in the vicinity of the seed plot. The position of the plot should be selected so that it does not lie in such a way that the prevailing winds will carry spores from wheat fields in the vicinity. In the selection of the seed plot the location of neighbors' fields should be taken into consideration as well as those of the owner.

Treatment of Seed.—The seed to be used in the seed plot should first be carefully cleaned and treated by the modified hot water method to rid it of any fungus which might be in the seed. It cannot be too strongly emphasized that this method must be used with great care. Seed should first be soaked in water at ordinary temperature, 65° to 70° F., for from five to seven hours. After soaking, the seed should be divided into small lots and placed in coarse sacks, not more than one peck to the sack. This is important in order that the seed can be quickly brought to the desired temperature. Provide two tubs or vats of water. The water in both these tubs should be maintained as nearly as possible at a constant temperature of 130° F. The grain in the sacks is first dipped in one tub for a moment and then transferred quickly to the second, where it remains for 10 minutes keeping the grain agitated while immersed. The water in the second tub must be kept constantly at the required temperature. Some method of providing hot water should be arranged so that water may be added as needed to keep the temperature at the point mentioned. If the temperature should rise above 130° or fall below 125°, the time for immersion must be modified accordingly. Standard thermometers must be used, as it is important that the temperature of the water be as nearly exact as possible. After the seed is treated it should be dried. It is not necessary to dry the seed completely. It may be planted as soon as it is possible for it to pass through the drill, though on account of the swelling it will be necessary to set the drill accordingly. It has been found, however, that the seed germinates better after allowing it to dry carefully before seeding, and, if carefully dried, the seed may be treated several months before planting. Two men can treat a bushel of grain in an hour by this method or enough seed in a day to sow a seed plot of six to 10 acres.

Seed plots should be maintained as long as there is any smut present on the farm. If seed is grown in an isolated field, and there is no smut present, it would not be necessary to treat the seed. As above stated, however, there is danger of contamination from neighboring fields and smut may be present in considerable amounts without its occurence being realized, since it does not show up at harvest time.

Covered Smut of Barley.

The covered smut of barley is mature late in the season, about the harvest time of the host plant, and is disseminated partly by the wind and partly through threshing. The appearance of the disease is somewhat like that of covered smut of wheat though the infection of the head is more general. Fig. 70 illustrates the general appearance well. The smut appears about two weeks later than the loose smut of barley. The smut masses may break and be blown about, though there is always considerable smut in the heads

at harvest time. The life history of the fungus causing the covered smut of barley is essentially the same as the life history of the covered smut of wheat or the loose smut of oats, and the method of treatment is the same as directed for those smuts. The formalin treatment is especially recommended.

Loose Smut of Barley.

Loose smut of barley is similar, in many respects, to loose smut of wheat. The life history and general appearance are essentially the same. The loose smut appears in the field about two weeks earlier than the covered smut and practically all of the head exposed, as shown in Fig. 71, is reduced to a smutted mass. This is blown about by the wind at the blossoming time of the host plant and consequently there is little left except the naked stalk at harvest time. Since the life history of this disease is the same as that of the loose smut of wheat and the fungus is present in the tissues of

Fig. 70. Covered smut of barley.

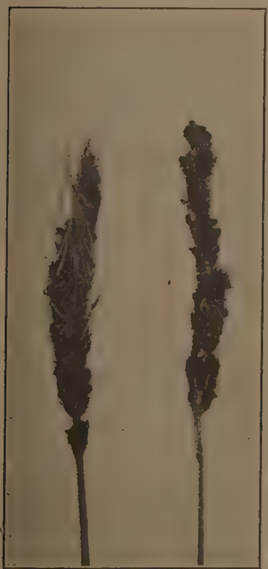

Fig. 71. Loose smut of barley.

the affected seed, the modified hot water treatment, as described in connection with the loose smut of wheat should be used. The temperature of the water, however, cannot be as high for barley as for wheat, since it is found that the barley seed is more susceptible to injury. The general method of procedure is the same, but the seed should be treated for 15 minutes in hot water at a temperature of 125° F. Should the temperature, for any reason, rise above this point, say to 127°, immersion should be reduced to 10 minutes, or at 130°, to five minutes. The temperature should not, under any conditions, be allowed to rise higher than 130°. If the temperature should fall below 125°, the time of immersion

should be increased. It should not be allowed to fall below 124°, as the treatment would then prove ineffective.

The seed plot may be used in connection with this smut as described for the loose smut of wheat.

ALFALFA AND CLOVER DISEASES.

Crown Gall.

This is a comparatively new disease in North America. It was first observed in this country in California in 1909, and has since been found elsewhere only in Arizona and Oregon. This disease was first called to the attention of the writer in May, 1911, when specimens of alfalfa crowns affected with this disease were sent in from Josephine county. Since that time it has been reported from a number of sections in Jackson and Josephine counties. It is probable that the disease occurs also in other localities, but our attention has not, as yet, been called to it.

The disease was first described from Equador in 1892, and has since been reported from a number of sections in Europe, notably Germany, Bulgaria and England.

So far as is known, the disease affects only the alfalfa. Experiments carried on in an attempt to grow it on clover and other plants have failed.

Symptoms.—The disease is characterized by the formation of galls at the crown of the plant. The galls are more abundantly produced at the base of the stem, but may occur on the upper part of the root. See Fig. 72. The galls in some cases occur several inches above the ground on the stems. They present a very much roughened exterior and vary in size from that of a pea or smaller up to four or five inches in diameter. In form they are often confluent.

Seriously affected plants are killed. Usually the disease will be found in the field in patches in which many of the plants are dead or in various stages of decline. The diseased plants are of a weak growth; the foliage is yellow and the leaves are reduced in size.

Cause.—Crown gall of alfalfa must not be confused with the familiar crown gall of trees, small fruits, etc. It is not the same, and it is unfortunate that there is similarity in the common names. Crown gall on trees and small fruits, as noted in another part of this report, is a bacterial disease.

Crown gall of alfalfa, on the other hand, is caused by a fungus of low order, known technically as *Urophlyctis alfalfæ*. This is one of the *Chytridiales*, one of the lowest orders of *Phycomycetes*. In this group the mycelium is sparingly developed. The presence of the fungus in the tissues, however, causes a stimulation which results in an abnormal development of the cells of the alfalfa at the point of attack. On the mycelium, resting sporangia are produced by a simple sexual process. These are found in groups in small cavities in the tissue of the gall. These groups may be observed with the aid of a good hand lens, by making a cut through a fresh gall. The sporangia are liberated by the rotting of the galled tissue and serve to spread the disease. When they germinate they produce a number of small motile spores which cause the infection of new plants.

It is probable that the disease has been introduced into the state through seed. It might be disseminated through alfalfa hay. It is possible that it might be carried some distance by the wind and might be spread locally from one part of a field to another or into new fields by accidental transfer of soil in which resting sporangia are present or in which there are bits of decayed galls. This might occur from driving across a field in which the disease is present and carrying the infectious material in soil on the wagon wheels or hoofs of the horses.

Remedy.—No remedy is known. When the disease becomes so serious as to render the field unprofitable, a rotation of at least three years' duration to other than leguminous crops should be practiced. The disease might be prevented from spreading in a field, if the spots are observed soon enough, by a complete destruction of the diseased plants. It might be advisable also to hoe the top soil toward the center and thoroughly spray the ground with copper

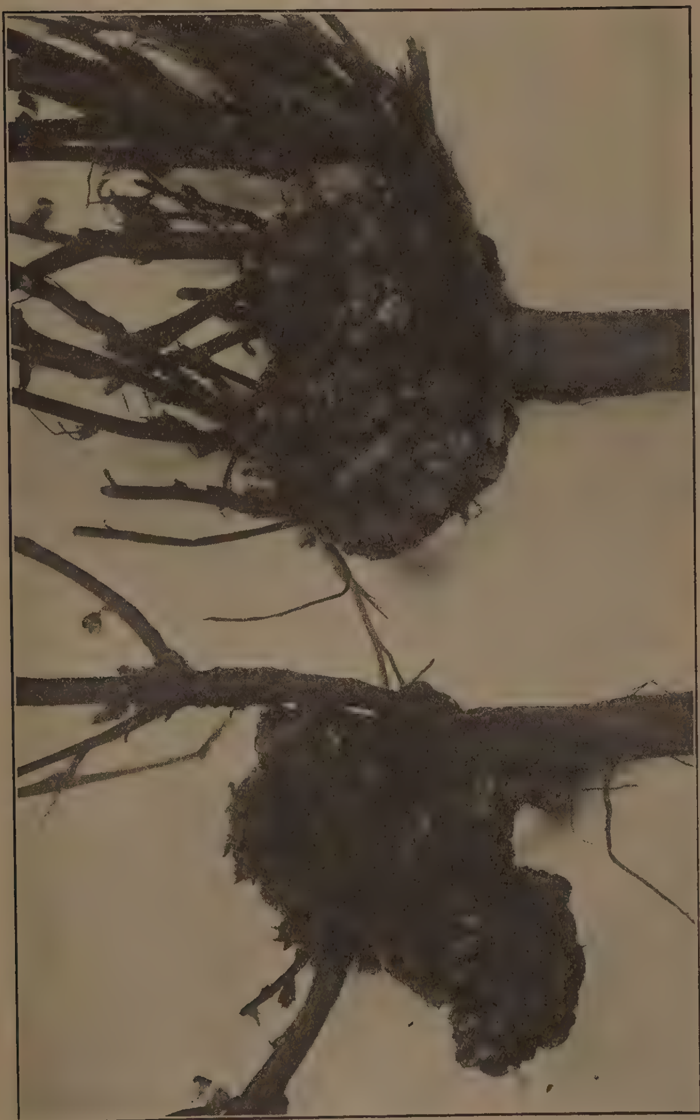

Fig. 72. Alfalfa plants attacked by crown gall. Note the distorted area occurring most commonly on the bases of the stems.

sulphate or Bordeaux mixture. As a general precaution, it might be well to avoid purchasing seed from localities in which the disease is known to exist. Seed disinfection might perhaps be practical, but this has not been demonstrated. Crown gall is a serious disease, and if it becomes general in the state, is likely to cause great loss. It is hoped that all growers will be on the lookout for the trouble and will use every effort to prevent it from spreading. Little is known of the disease as it occurs under American conditions. A thorough investigation of the trouble would be desirable.

Dodder of Alfalfa and Clover.

A trouble of alfalfa and clover common in Oregon and somewhat different in nature from any of the diseases previously discussed, is caused by a parasitic flowering plant known as dodder. The dodders are weeds which, as causing a disease of clover and alfalfa, are known to be common throughout the world, including nearly all sections of the United States where these crops are grown.

Kinds of Dodder.—Contrary to the usual idea, dodder in clover and alfalfa is not caused by a single kind or species, but by several different species of dodder which may exist upon these hosts. *Hillman gives five species of dodder which are known to affect alfalfa and clover in the United States. Concerning these he offers the following information:

"Clover dodder *(Cuscuta epithymum*, often referred to as *Cuscuta trifolii)* infests both the true clovers and alfalfa indiscriminately. It is widely distributed in foreign countries and in the United States east of the Mississippi River and in the Northern Pacific States.

"Small-seeded alfalfa dodder *(Cuscuta planiflora)* as it occurs in this country appears to confine its attacks to alfalfa in preference to the true clovers. Thus far there is no evidence of any damage from this dodder to red, alsike, or white clovers. This is by far the most abundant and destructive of the dodders in the Western States.

"Field dodder *(Cuscuta arvensis*, as recognized in the botanies) is widely distributed throughout the United States. It infests both the clovers and alfalfa and also many wild herbaceous plants. It has proved injurious to sugar beets in Utah.

"Large-seeded alfalfa dodder *(Cuscuta indecora)* is common in the West, especially in Utah. It infests alfalfa as well as various wild plants, but it does not appear to damage the true clovers.

"Chilean dodder *(Cuscuta racemosa chileana)* is not generally known in this country. It is common in South America and has been reported from Europe. It is said to have flourished for a time in California many years ago, but subsequently disappeared. It is of interest because of its prevalence in alfalfa and red clover seed-producing regions of South America, from which seed is being sent to the United States, for this dodder infests both alfalfa and red clover. Little is known of this dodder in its relation to forage crops in this country, but since it is being brought here in considerable quantity from South America it is very likely that it will become one of the several injurious species established in the United States."

The species of dodder occurring in Oregon have not been studied thoroughly in the field, consequently no accurate information can be given at this time as to the species which are most common in the state. The three most common ones found in alfalfa seed in the Northwest are *Cuscuta planiflora*, *Cuscuta arvensis* and *Cuscuta indecora*. *Cuscuta arvensis* is common upon clover as well and *Cuscuta epithymum* is also common in this state.

Appearance in Field.—Dodder may be recognized at a distance by the yellow appearance of spots in the field. At close range this appearance will be found to be due to the abundance of the yellow thread-like dodder plants which twine about the stems of the alfalfa or clover. At first the dodder will be seen only in a small area, infecting one or two plants. It rapidly spreads in all directions by branching of the threads from these to other plants till large areas are covered. During this spreading, the plant first infested will gradually be killed by the parasite. The dodder dies with it, but continues to grow along the edges of the spot, so that, in the late season, dead spots surrounded by a circle of dodder infested plants may be observed in alfalfa or clover fields. The dodder in the meantime has blossomed profusely and ripened its seed.

Dodder in General.—The dodders, or love-vines, are parasitic flowering plants closely related to the morning glories, or bind weeds. There are several species occurring in this state besides those species which attack alfalfa and

*Hillman. Dodder in Relation to Farm Seeds. U. S. Department of Agriculture, Farmers Bulletin 306, 1907.

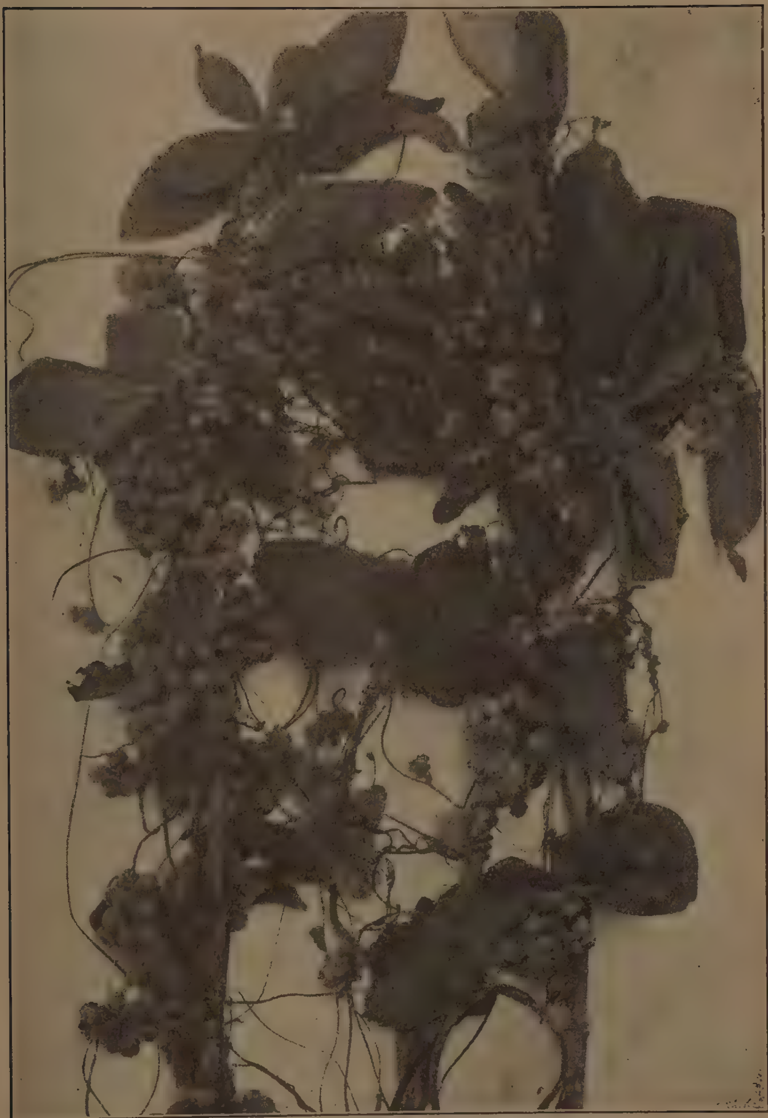

Fig. 73. Clover plants attacked by *Cuscuta arvensis* and clover dodder. Note the abundance of blossoms and seed pods.

clover. Most of these grow on weeds, particularly in moist bottom lands, and do no damage to the farmers' crops.

These plants are peculiar in that they are parasitic in habit, depending on the plants upon which they grow for their food, instead of elaborating it for themselves from the soil moisture and air as plants possessing green color are able to do. Dodders are destitute of this green color called chlorophyll and so have not the power of elaborating food for themselves. The plant consists of a yellow stem which is practically leafless. The leaves have been reduced to very small scales. The flowers are minute and are usually produced in clusters on the stem.

Life History.—During the first stages of growth the young dodder plant is self supporting, but is wholly dependent on the food stored in the seed. The seed, when it first germinates, consists solely of a yellow thread-like stem. The plantlet may or may not attach itself to the ground. It grows independently until the food in the seed is used up. During this time the thread-like stem has grown sufficiently to grasp and twine about some green plant growing near by. If this green plant is not one upon which the particular species of dodder naturally grows, it dies. If the plant is one for which the dodder has a natural affinity, it twines about the stem and sends suckers or haustoria into the tissue, thus linking the two plants together. The haustoria serve both as holdfasts for the dodder's support and as feeding organs through which the dodder takes the juices of the host, depriving it of needful food which it has manufactured for its own use. Fig. 74 shows a thin cross-section of an alfalfa stem highly magnified, and the dodder attached to it. Note the manner in which the two are grown together. Growing in this way the dodder blossoms, matures its seed, and dies. Usually the host plant is killed or much weakened by this parasitism.

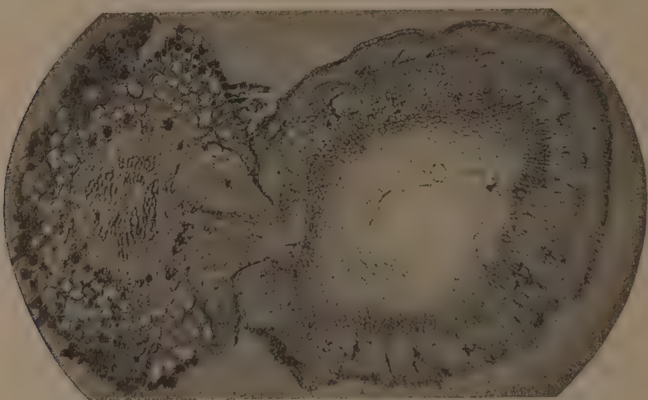

Fig. 74. Photomicrograph of a section of alfalfa stem attacked by dodder. Alfalfa stem in shown at the right, dodder at the left. Note how the dodder attaches itself to the tissues of the alfalfa, enabling it to absorb both water and elaborated food. Magnified 34 diameters.

Propagation and Dissemination.—Dodder is most commonly distributed by the seed being mixed with the seed of the host plant. The various species of dodder are common in the districts where alfalfa and clover seed are grown and the seed of both host and parasite are matured about the same time, consequently when an infested crop of clover or alfalfa is harvested, the seed is usually found contaminated with a certain percentage of the dodder seed. In this way the disease is disseminated far and wide. The mixed seeds germinate when planted, whereupon the dodder soon attaches itself to the

clover or alfalfa, and after becoming permanently established on one plant may be spread from plant to plant in the field, slowly infesting considerable areas.

When dodder is established in the field it may be disseminated by seed to other parts of the field during mowing and raking. The dodder plant may remain alive for several days on the host plant after it has been cut, and if such diseased plants or parts of plants are scattered to other parts of the field the dodder may obtain a foothold on new plants and thus start other spots. It is shown that in New York dodder *(Cuscuta epithymum)* may live over winter on the crowns of infested plants. It is not known whether this happens in Oregon or not. The seed of the small-seeded dodder which is so common in the West, may be spread by irrigation water.

Preventive Measures.—Since dodder is disseminated almost exclusively through the seed, the most obvious method of preventing the introduction of this trouble is by planting clean seed, that is, seed which has no dodder mixed with it. Certain species of dodder infesting alfalfa may be entirely removed by proper screening. The large-seeded species of dodder cannot be entirely removed by any process of screening known at the present time. White and Alsike clover, on account of their small size, cannot be entirely freed from dodder. Red clover, by thorough re-cleaning, can be entirely freed of clover and small-seeded alfalfa-dodder. The size of the screen is important, but sufficient space is not available here for thorough discussion of the processes of separation.

The most logical precaution to take is never to plant seed infested with dodder. This can be accomplished by buying only the best of re-cleaned seed and having it previously tested by an expert for the presence of dodder. A seed laboratory is carried on in connection with the Department of Agronomy of the Oregon Agricultural College, and any seed sent in for inspection will be given careful attention. Write for directions in regard to the proper method of taking samples.

When dodder becomes introduced into a field, the method of eradication is frequently difficult, depending upon the location of the field and the species of dodder. Space will not permit a detailed discussion here of the methods of eradication, and interested growers should apply for information to the Experiment Station, giving a full statement of conditions, or should procure a copy of the farmers' bulletin above mentioned, in which the methods of eradication are fully discussed.

Leaf Spot.

The common disease of the alfalfa known as leaf spot is prevalent in most section of the country where alfalfa is grown. It is also the most common fungous disease on this crop in Oregon, but under ordinary conditions is not responsible for large losses.

Symptoms.—The disease is characterized by the formation of brown or black irregular spots on either side of the leaf. The spots are most conspicuous, however, on the upper surfaces. They are small, seldom over one-eighth of an inch in diameter, and are scattered irregularly but frequently very thickly over the surfaces of the leaves as shown in Fig. 75.

Cause.—In many of the spots the presence of little shining amber-colored structures with black margins may be observed by the aid of a good pocket lens. These are the fruiting bodies of the fungus causing the disease which is known technically as *Ps udopeziza medicaginis*. These structures are the apothecia or fruiting bodies of the fungus and contain, in a layer on the upper surface, many cylindrical sacs, called asci. Eight spores are formed in each of these asci.

The general effect of these spots on the leaves is to cause them gradually to turn yellow and fall, so that the plants, where severely affected, may be almost entirely stripped of foliage. This brings about reduction in forage, and, on account of hindering the normal development of foliage, results in interference with root growth which may cause reduction in subsequent crops.

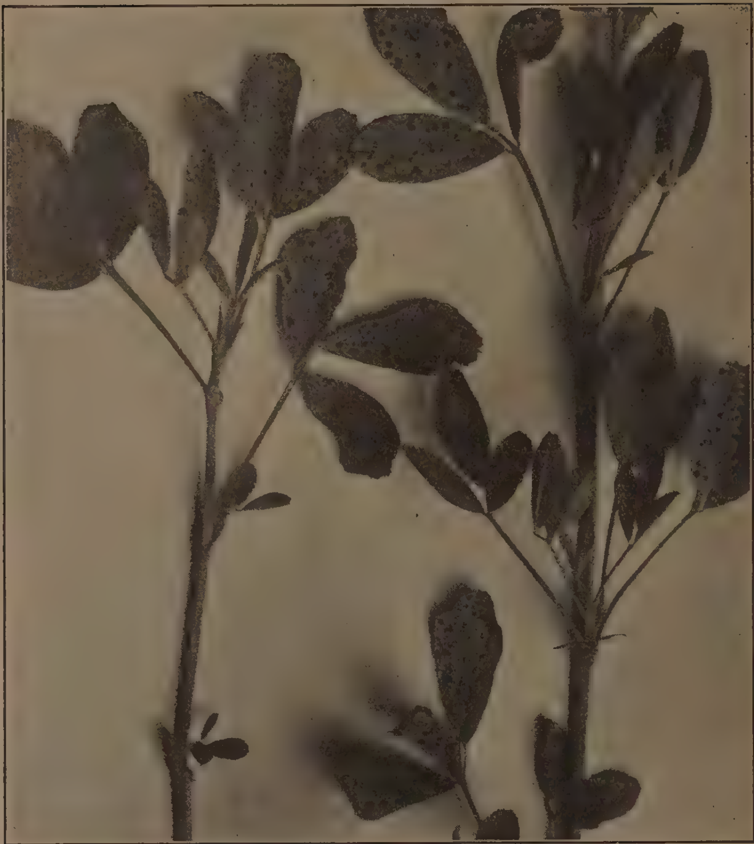

Fig. 75. Alfalfa stem showing spots of *Pseudopeziza medicaginis* on foliage.

In Western Oregon the fungus is most abundant in the fruiting condition in the fall, when mature spores are produced in large numbers from September to December. It is possible that the fungus, under Oregon conditions, spreads all winter. It is probable that the fungus is disseminated locally most frequently by the wind, but there is evidence to show that it may be carried to new localities through the seed.

A similar disease, which is considered by some authorities as identical with the alfalfa leaf spot, but which is usually referred to by scientists as *Pseudopeziza trifoliorum*, occurs in Oregon on red clover.

Remedy.—On account of the nature of the host crop, no very satisfactory remedy for this trouble suggests itself. When the disease appears to be serious in the spring so that the leaves drop abundantly and the forage value is likely to be much reduced in the first crop, it might be advisable to mow the plants early, as this would cause a tendency to throw out new sprouts which would grow vigorously and might escape the disease. It is also recommended that where it becomes abundant prior to cutting any crop, the plants be mowed a little earlier than usual in order to save loss of foliage.

This disease is seldom serious enough to warrant plowing up a field. Should it ever become so, rotation to other than leguminous crops should be resorted to.

Wilt or Stem Rot.

The disease known as the alfalfa wilt is common. It was first described in Europe but is also recorded in many widely separated sections of this country. It has been reported as serious in New York and California and has recently been found by the writer to be common in Oregon. It was first observed in certain fields in the Willamette Valley. It is found to be most abundant and to spread most rapidly during the fall, when the surface of the ground is more or less constantly moist. It seems to be more serious also where there is a heavy stand of alfalfa.

The disease is known to attack clover almost as seriously as alfalfa. It is probable that this disease is one of the causes for the difficulty frequently experienced in obtaining and holding a stand of alfalfa or clover in Western Oregon.

Symptoms.—The disease is characterized by a wilt brought about by rot developed on the stems at the surface of the ground or some distance baove. The disease frequently kills the plants and on this account large areas

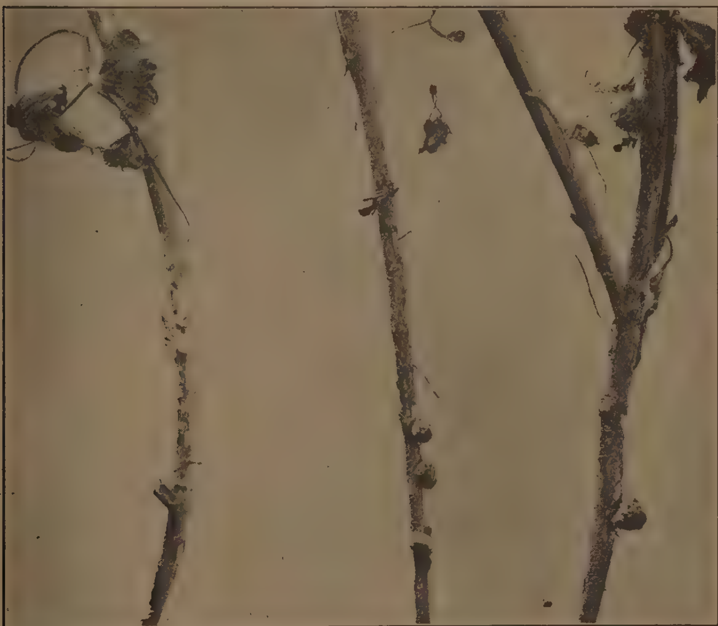

Fig. 76. Stems of alfalfa attacked by stem rot fungus. Note growth of white mold on the surface and the presence of sclerotia associated with this mold.

may be found in the field where the plants have been entirely killed out. The roots, however, may not always be destroyed, and may later throw out new sprouts. The rotting is invariably accompanied by a white cottony growth of mold over the surface of the stems and leaves and on the ground around the bases of the diseased plants. In this cottony mold are developed, quite abundantly, black irregular shaped bodies of fungus tissue known as sclerotia.

Fig. 77. Fruit bodies of wilt fungus developing from sclerotia. Natural size.

In exceptional cases these are as large as a pea. They may also be found inside the stems of plants which have been killed by the disease. Fig. 76 shows these sclerotia developed on the surfaces of the stems.

Cause.—This fungus is similar to the one which causes lettuce drop and by some authorities is considered identical, though this has not been proved by careful investigation. It seems best for the present to consider it distinct and to use the name *Sclerotinia trifoliorum*. This fungus develops no summer spores. The cottony growth is the mycelium which is also developed inside the tissues. The sclerotia are resting bodies from which there develops, as shown in Fig. 77, stalked fruiting bodies known as apothecia. These are usually described as developing only after a period of rest, commonly in the spring of the year in nature. In Oregon, however, they are found developing in fall, almost immediately after being formed, without any period of rest. Under our conditions the disease seems to spread most abundantly during the fall and winter, though this has not been as thoroughly investigated as would be desirable.

Remedy.—No remedy for diseased plants is known. On account of the nature of the host plants, it is probable that no practical remedy will be developed. Where the disease has become serious, rotation should be practiced. The disease seems to be more abundant on heavy soils, especially where the drainage is not rapid, and such soils, if possible, should be avoided.

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